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VOL. 21 DECEMBER, 1929 No. 12

## THE TORONTO WATER WORKS SYSTEM[1]

By R. C. Harris[2]

The City of Toronto lies on a plateau gradually ascending from the northern shore of Lake Ontario and is situated about due north from the mouth of the Niagara River. The altitude ranges from the Lake level zero, 245 feet above mean sea level at New York, to a maximum of 610 feet in the North Toronto district. The total area is 41.3 square miles, which includes 6.4 square miles of land covered by water, i.e., the harbor and a small portion of the Lake. The harbor proper, approximately $1\frac{1}{4}$ square miles in area, is formed by an island lying to the south of it. There are two small rivers, not commercially navigable, the Humber in the west discharging to the Lake, and the Don in the east center flowing into the harbor.

Toronto owes its origin to the French who built a fort and started a small trading settlement in 1749, under the name Fort Rouille. In 1793 it became the capital of Upper Canada and was renamed York. In 1834, the population having increased to 9,254, the municipality was incorporated as a city and given the name Toronto, which is of Indian origin, denoting "a place of meeting."

The population of the City proper is now 585,628 according to assessors' figures. Since 1912 the area of the municipality has re-

[1] Presented before the Toronto Convention, June 26, 1929.

[2] Commissioner of Works, Department of Works, Toronto, Canada.

mained practically unchanged, it being the policy of the Corporation to concentrate upon the provision of municipal services required for the existing City and not to encourage, without compensating advantages, the annexation of bordering municipalities. There is a large suburban population of about 80,000, immediately adjacent, to a portion of which, the City in 1928, supplied 881 million Imperial gallons of water.

The service most essential to the well-being of the citizens is that of water supply and distribution. Toronto's first water works pumping engine was erected in 1841 by a private company known as "The City of Toronto Gas, Light and Water Company" which was incorporated in that year by the Parliament of Canada, and in 1842 entered into a twenty-one-year contract with the municipality for the supply of water for fires. This Company also served the greater part of the City with domestic service, the supply being secured via a wooden conduit from the Bay. Many wells were in use. In 1851 the works were taken over by the Metropolitan Water Company, but prior to 1873, the original owners had again secured control.

As early as 1854, trouble was experienced through lack of supply, and at that time the Company offered to sell the existing works to the City for 35,000 pounds sterling. This offer was not accepted, but proposals were secured for the creation of a system to be owned by the municipality. A comprehensve report was presented by T. C. Keefer, C.E., in 1857, but was not acted upon, and the citizens suffered for a further period of fifteen years with what was characterized, even by the directors of the Company, "as a deficient supply of impure water" which was furnished at exorbitant rates. In 1872, in consequence of considerable public agitation, the City secured enabling legislation for the appointment of a Board of Water Commissioners and the construction of a water works system. Plans were at once prepared, and in 1873, after some negotiation, the Company sold its plant to the municipality for $220,000.

The Board of Water Commissioners decided to establish a municipal plant of sufficient capacity to serve three times the then population, which was 68,000.

Consideration was given to the various sources of supply which had from time to time been mooted, the Don and Humber Rivers; Bond Lake and Lake Simcoe many miles to the north of the City; Toronto Bay, rejected as being unfit for use; and finally, various sites along the north shore of Lake Ontario from Scarboro on the east to

the Humber on the west. Lake Ontario was selected as the logical source of supply.

It was deemed necessary to avoid turbid water as not suitable for drinking purposes, which would have involved the provision of an intake with inlet about 2 miles from shore. The intake proposed was abandoned on the score of expense and in lieu an infiltration basin was excavated on Toronto Island, to which the water found its way by natural infiltration. This basin was originally designed to store 20 million Imperial gallons, but as built had a capacity of about 4 million gallons.

Other features of the system, which was constructed during the period 1873–1877, were: a 48-inch wooden stave pipe laid across the Island; a 36-inch cast iron pipe (with flexible joints) running therefrom across the Bay to the pumping station, which was located contiguous to the existing main pumping station on the bay front at the foot of John Street; feeder and distributing mains of 24- and 30-inch diameter; and a reservoir (still in use) of 33 million Imperial gallons capacity, located in the northern section of the City at an elevation of 215 feet above the Lake, and functioning as storage for excess pumpage during periods of minimum demand.

In the first few years, many difficulties were encountered. Sections of the 48-inch wooden conduit in Blockhouse Bay at the Island rose to the surface in 1874, due to being laid without cover. Owing to the inadequacy of the filter basin, channels were cut in 1877 to connect the Lake therewith. Wooden conduits leading from these channels, became choked at times of storms, and it became necessary to take water from a settling basin farther inland and nearer Toronto Bay, where the water was frequently impure. In 1878 the City Engineer assumed control, acting under a Water Works Committee of the Council and in the following year abandoned the filter basin which had definitely proven a failure. In 1881, a 6-foot wooden stave pipe nearly $\frac{1}{2}$ mile long was laid direct from the Lake, the mouth being in 25 feet of water.

It appears from the records that, in 1881, all wells throughout the City were discarded and the entire water supply taken from the City's works. Four years later, in 1885, a separate City Water Works Department was formed.

By 1888 the consumption had nearly reached the capacity of the 48-inch conduit and Rudolph Hering and S. M. Gray were retained to advise on extensions to the system. Following their recommenda-

tions, a 72-inch steel extension to the stave conduit was laid 361 feet southerly into 60 feet of water, a 60-inch steel pipe was laid across the Island to the northerly shore crib, and a 48-inch steel pipe placed on the floor of the Bay connecting with the pumping station at John Street. A High Level pumping station with two 3-million gallon pumps was constructed on Cottingham Street, approximately 2½ miles north of the John Street station, for purposes of repumpage, and still exists in extended and modernized form. These improvements were completed in 1891.

In 1892, sections of the conduit in the bay near the Island, rose to the surface in consequence of the pipe being emptied by the John Street pumps while blocked at the Island screens by weeds. In 1895 further breakages occurred in supply conduits due to the accumulation in them of sand and other obstructions, coupled with the extremely low water level then prevailing in Lake Ontario. Water had to be drawn from Blockhouse Bay at the Island for a few weeks. As an outcome of public unrest, James Mansergh, a noted English engineer, was retained to report upon the situation. After thorough examination into the several alternative sources of supply which had been suggested, he recommended the continuance of the existing source, Lake Ontario; the construction of a steel intake in place of the wooden stave pipe and the driving of a tunnel under the floor of Toronto Bay. By 1898, the 72-inch steel intake pipe, 2363 feet long, had been laid, extending 2220 feet from the shore. It was not until 1905 that the tunnel was commenced, being completed in 1908. This tunnel is 5087 feet long, of horseshoe form, equivalent to a diameter of 90 inches, the lower half being of concrete and the upper half a brick arch.

Owing to pressure from insurance and commercial interests, a high pressure fire system serving the central business section of the City was completed in 1908. In the same year Allan Hazen was engaged to prepare plans for a filtration plant, the work being commenced the following year and completed in 1911. This slow-sand plant situated on Toronto Island has a normal capacity of 40 million Imperial gallons per day. It was found to be too small for increasing requirements. Including land, proportion of wharf, etc., it cost $943,522.

In 1910, and early in 1911, breakages occurred on the steel intake. The water supply was derived from basins and channels on the Island until a temporary intake was placed at the end of June. Meanwhile, the steel intake was reinforced with steel piling and concrete, for a

distance of about 1200 feet from shore and by the end of August was again in commission. These frequent breakages and interruptions greatly unsettled the public mind. The quality of water during the early part of 1911 was not good and an outbreak of typhoid fever eventuated. Great concern was manifested. Many different projects were advanced and a board of four independent consulting engineers was constituted. Their recommendations included the continuance of the present source of supply and the construction of a duplicate system with source at Scarboro Heights, about 9 miles to the east of the existing intake.

The source at Scarboro Heights was chosen by the Board because of freedom from possible contamination, the general trend of the lake currents being from east to west. The City's engineers were convinced that it was unnecessary to go so far east for a potable supply, having regard for facts demonstrated by investigation, and the further conclusion that filtration and chlorination would in any event have to be invoked. We recommended in 1913, that the intake and works should be located at or about the eastern City limit, which is 6 miles from the existing intake and 3 miles west of the site recommended by the board of consultants. The World War intervened and prevented further development of the duplicate system, but to cope with increasing demands, many improvements and extensions were made to the system. A second 72-inch steel intake was laid at a cost of $260,000, extending 2403 feet from shore and situated a short distance west of that constructed in 1898. This was placed in commission in February, 1913. An 84-inch steel conduit was placed across the Island to connect the Filtration Plant with the tunnel, this work being done during the period 1913–1916 at an outlay of $639,-532. A second filtration plant was built at the Island, having a normal capacity of 60 million Imperial gallons per day. This unit was partially used in 1916 and was placed in full operation in 1918. It is of the drifting sand mechanical type. It cost $1,203,036, including land, reservoir and wharf. A number of 36- and 42-inch feeder mains were installed in the distribution system, and the pumping capacities of the main or low level, and high level stations, respectively, were greatly increased.

The water works system when I assumed charge in 1912, had no reserve pumping capacity at the low level station at John Street, and extensions and alterations had to be seriously considered and promptly undertaken. The plant consisted of two separate boiler and

pump rooms and the problem was to make the alterations without interrupting the supply. This was accomplished without cessation of service. To operators, it may be of interest to know that, with the present equipment, we are pumping double the quantity of 1912, with no increase in staff.

Intake trouble has been experienced only once since 1911. In 1921 a break in the old intake was discovered, just south of where the sheet piling and concrete had been placed in 1912–1913. A temporary intake mouth, which had been stocked against such a contingency, was at once fitted between the point of rupture and the shore line and the supply was not interrupted. Subsequently the pipes were reconnected, and sheet piling and concrete was extended southerly a distance of 545 feet. The intakes are inspected by divers at two-week intervals, when possible, throughout the year, in order that continuity of supply may be assured. Inspection is quite hazardous owing to exposure, ice conditions, etc.

## DESCRIPTION OF PRESENT SYSTEM

A general description of the system may be of interest. The source of supply is approximately 2 miles south of the Royal York hotel, off the south shore of Toronto Island, where two 72-inch steel intakes extend into the lake 2220 feet and 2403 feet, respectively, the inlets being at depths of 42 and 79 feet. The water is pumped from the intake shore cribs to the filtration plant, where it is purified by the filtration processes already referred to, and treated with chlorine. When the raw water is not susceptible to taste, a normal dose of chlorine sufficient to insure sterilization, is applied to the filtered water. When the raw water is susceptible to taste because of its chloro-phenol content, a system of "superchlorination" is employed, involving the use of larger quantities of chlorine and subsequent application of sulphur dioxide to neutralize the residual chlorine content.

In the slow sand filter plant (in use since 1912) there are 12 filter beds, each four-fifths of a acre in area. The drifting sand, or mechanical plant, (placed in complete operation in 1918) consists of 10 filters, each 50 feet in diameter. The pumping equipment consists of one steam pump of 50 million gallons daily capacity, and 7 electric pumps having a total capacity per diem of 193 million Imperial gallons. After filtration, the water flows to a clear water reservoir, and thence by gravity through 72- and 84-inch conduits, northerly across the Island to the south shaft of the Tunnel built under the Bay. The

tunnel connects with the main or low level pumping station situated on the waterfront at the foot of John Street. At this station, dechlorination by the introduction of sulphur dioxide is carried out when necessary. The pumping equipment consists of five steam pumps, with a total daily capacity of 102 million Imperial gallons and six electric pumps of 110 million Imperial gallons rated daily output.

From the low level station, water is pumped through the distributing mains to the various sections of the City, and to the high level station, the excess pumpage flowing to the Rosehill Reservoir. This reservoir has a storage capacity of about 33 million Imperial gallons, and covers an area of 13 acres. Water is drawn from the reservoir at times of heaviest demand. The topography is such that it is necessary to divide the City into five pumping districts; district 1, comprising all that section of the City lying south of College, Carlton and Gerrard Streets, being supplied direct from the low level station. The four upper level districts are supplied by means of repumpage from the high level, Riverdale and East Toronto Stations. The minimum pressure in each district during period of maximum demand, is approximately 35 pounds, with a maximum of about 75 pounds according to elevation.

At the high level pumping station there are 7 steam and 8 electric pumps, the former having a capacity of 90 and the latter 66 million Imperial gallons.

Under normal conditions, the pumping equipment is electrically driven, but a steam reserve under banked fires is maintained at both the main and high level stations.

Two booster pumping stations, with two water towers, are maintained to increase pressure in outlying districts.

We are justly proud of the purity and clarity of Toronto water. Tests for purity are made hourly at the Department of Public Health laboratory at the Filtration Plant, and at longer intervals from samples taken from the City mains by the laboratory of that Department at the City Hall. These show the water to be uniformly pure and potable, as is evidenced by our typhoid death-rate, one of the lowest on the Continent.

We are fortunate in having a most efficient Department of Health presided over by Dr. C. J. Hastings, who has earned world-wide recognition for his accomplishment in public health service. By stringent regulation and vigilant inspection of milk and food supplies,

coupled with a supply of water unexcelled in purity, the death rate from typhoid has been reduced to a point relatively negligible. In 1912, the death rate from typhoid was 13.2 per 100,000 of population; in 1928, it was 0.9 per 100,000 and each of the latter cases was conclusively proven to have originated outside the City.

## FINANCIAL DATA

The depreciated value of the water works plant as of December 31, 1928, was approximately $19,000,000.

There are 55 miles of pumping mains ranging in size from 16 to 42 inches. Domestic mains, in sizes up to 12 inches, aggregate 631 miles. There are 134,853 water services, 7625 domestic pressure fire hydrants and 173 hydrants on the high pressure fire system. The stop or gate valves total 8383 and there are 299 check valves. In the early years of electrical operation of the pumps at the main or low level station, we had considerable trouble due to breakages of check valves in consequence of water ram caused by failures of electric power. Since the installation of large air chambers on each pumping main, this disability has vanished.

The total amount of water pumped in 1928 was 27,271 million Imperial gallons, a daily average of 74.5 million Imperial gallons. Deducting the quantity supplied outside the City, 881 millions, which is a daily average of practically 2.4 millions, there was a net City consumption of 72.1 million gallons. Based on a population of 585,628, this represents a per capita daily consumption in the City, of 123 Imperial gallons, which is the equivalent of 148 U. S. gallons. Forty-eight per cent of the water was repumped in 1928. In the sixteen-year period, 1912–1928, the average daily consumption has increased from 46.9 to 74.5 million Imperial gallons, an annual rate of increase of 2.9 per cent. The annual rate of population increase in the same period was 2.1 per cent. Our maximum consumption for one day was 96.99 million Imperial gallons, on June 8, 1925, an average of 177 Imperial gallons per capita per diem as of that date.

Most of the large services, including those for manufacturing purposes, are metered, at the rate of 13.75 cents per thousand Imperial gallons, subject to a discount of 10 percent for prompt payment, or 12.4 cents net. Practically all of the water supplied outside the City is metered, either at the special rate of 20 cents per thousand Imperial gallons net, under agreement with the municipalities, or at 33.75 cents net, to individual consumers. The great bulk of the

household services, are rated according to a sliding scale based on the number of rooms, occupants, taps, toilets, laundry, etc., all such being subject to a discount of 10 percent for prompt payment. The rates were raised in 1918 to meet adequately the increased cost of supply, consequent upon the extensive improvements which had been carried out. Since that time the system has been self-sustaining. The net surplus each year is consolidated with the ordinary revenue of the City, thereby reducing the general rate of taxation. Depreciation reserve is not set aside, capital improvements being financed by debenture issues on the credit of the City. When units wear out, new bond issues are made. This invariably occurs some time after the redemption date of the initial debenture. Our practice is in accordance with the special Water Works Act governing the system, but both the Finance Commissioner and I have urged that the net surplus should be applied to the financing of capital requirements. The system is exempt from taxation by Act of the Legislature. We do not furnish any "free service" either to the fire department or any other undertaking, municipal or otherwise. The value of the service rendered for "fire protection" was formerly computed at the flat rate of $30.00 per hydrant, which would aggregate about $227,000 per annum, with the present number of hydrants. In 1915, the hydrant charge was abolished, and instead a percentage of the total water works maintenance and debt charges has been annually applied. This percentage, which has varied between 35 and 37 percent, is ascertained each year by a revaluation of the water works properties, plant, mains, etc., considered on the basis of two services, domestic and fire, being served by a combined system. The value determined for each item of property and plant is apportioned in varying ratios between the two services, in the proportion that it is considered that the relative demands of the two rendered the original investment necessary. An item may be rated 100 percent domestic, such as filtration, another 100 percent fire, such as hydrants, and other varying percentages on mains, etc. The ratio of the totals on account of installation of the separate services, determines the percentage to be applied to the aggregate of charges for the combined system. For 1929 the percentage chargeable to fire protection was 35.9 percent.

## FINANCING EXTENSIONS

Water mains are laid under the following plans: (*a*) As a capital outlay financed by debenture issue; (*b*) as a revenue main financed

by the City and paid for by subsequent revenues from that particular main; (*c*) as a bond main financed by the City, the applicant furnishing a bond guaranteeing an annual payment equal to 10 percent of the prime cost, which payment continues until the revenue equals the guarantee; (*d*) as a local improvement financed by the City, the cost being assessed against the properties benefited on a foot frontage basis, in 10 annual installments, the City at large paying no portion thereof.

The tôtal expenditure on water works account in 1928 was $2,844,416, of which sum the debt charges represent $1,264,117, or 44.5 percent of the whole.

ADMINISTRATION

The existing arrangement for the administration of the Water Works has been in vogue since 1893, various methods of control having been employed prior to that time, as hereinbefore indicated. The operation, works and property are under the control of the Commissioner of Works, and the collection of revenue, financing, etc., is under the direction of the Commissioner of Finance. The Department of Works' organization for water works administration comprises three sections, functioning as follows: *Water supply*—charged with the construction and operation of intakes, filtration plant, pumping stations, reservoir, etc. *Water main extension*—controlling the construction and extension of mains. *Water distribution*—responsible for maintenance of mains, valves and hydrants, and installation and maintenance of water services, meters and street drinking fountains. In connection with the operations of the last-mentioned section, there is an efficient emergency service, two stations being maintained with relays of men always on duty, having at their disposal motor trucks completely equipped for expeditious action, so that bursts and leaks or like emergencies may have prompt attention. A machine and test shop is also maintained as a unit of this section.

HIGH PRESSURE FIRE SYSTEM

The high pressure fire system has been in operation since February, 1909 and is financed as a fire department charge. There are 10 miles of mains serving 337 acres in the congested business section. The system is so designed that any pressure up to 300 pounds per square inch may be attained during fire periods. Normally a pressure of 100

pounds per square inch is automatically and continously maintained. The hydrants, of which there are 173, are tested to 700 pounds pressure. There are three steam turbine pumps located at the main or low level pumping station, having a combined daily capacity of 20 million Imperial gallons. The water for the system is drawn from the Bay, and is entirely separated from the domestic supply. Since the original installation, the system has been once extended, an additional supply main has been laid and a third pump provided.

# THE NEW TORONTO FILTRATION PLANT AND OTHER EXTENSIONS[1]

By William Gore[2]

The existing water supply system of the City of Toronto and district covers an area of about 46 square miles. It is capable of supplying a demand averaged over all hours and seasons of 75 million gallons a day and a maximum at any time of 66 percent in excess of that amount. The reference herein to the gallon relates to the Imperial gallon which equals about one and one-fifth U. S. gallons.

The extensions about to be carried out in accordance with the Acres-Gore report of May 15, 1926, provide for an ultimate additional supply of water of twice the existing supply and include intake, pumping, filtration and distribution systems among the largest on the Continent.

The extensions are being designed so that construction work will be carried out in two stages providing in each stage for an additional average daily supply of 75 million gallons, but wherever it appears more economical to do so provision is made in the first construction for the complete scheme. Thus in the works about to be undertaken the intake tunnel, pumping stations, administration building, stores and supply building, main conduits, distribution feeders, reservoirs and tanks provision is made for an ultimate average daily supply of 150 million gallons, while in the remainder of the works including the filters and coagulating tanks provision is made only for an average daily supply of 75 million gallons.

The extensions are shown in their relation to the existing works in figure 1. The area of supply stretches along the northern shore of Lake Ontario a distance of about 10 miles and to the north a distance of about 8 miles measured from the existing filtration plants on Toronto Island. The ground surfaces within the area of supply rise more or less gradually up country to a height of nearly 400 feet

[1] Presented before the Toronto Convention, June 26, 1929.

[2] Of Gore, Nasmith and Storrie, Consulting Engineers, Toronto, Canada.

above the lake level. The difficulties of maintaining the proper pressures in the service pipes therefore lies both in the loss of head by friction in the pipes over the long distances traversed by the water and in the rising elevations of the ground surfaces, the more distant areas being at greater elevations. To meet this situation the water supply area hitherto has been divided into seven zones or districts with fairly uniform pressures in each. The new works are being laid out so as to reduce the number of districts to 5, one of which is on Toronto Island and supplied directly from the existing filter plants there. Districts 2, 5 and 5A will be merged to form one and the booster pumping stations at Riverdale in District 5 and at East Toronto in District 5A will cease to operate and there will be a general improvement in the pressure relationships throughout the areas of supply. The existing main pumping station at John Street will pump water into District 1 as at present, the water being supplied either from the existing filtration plants or from the new. Two new high pressure pumping stations will be constructed, one at the new filtration plant at the east end of the City at Victoria Park and the other at Sunnyside near the west end supplied by water by a low pressure tunnel from the new filtration plant, which tunnel also supplies the main pumping station at John Street. Both of these new pumping stations will pump into District 1 and the enlarged District 2. This includes the whole of the water supply except that of the Island as the remaining Districts 3 and 4 are to be fed by boosting the pressures from Nos. 1 or 2. The supply in District 1 will be balanced as at present by the existing 30 million gallons Rosehill Service Reservoir and similarly the supply in the enlarged District 2 will be balanced by the St. Clair 50 million gallon service reservoir to be constructed immediately. A new overhead ornamental tank to contain 300,000 gallons will balance the supply in District 3 and the existing standpipe in District 4 will be enlarged to form an overhead tank to contain 500,000 gallons which will balance the supply in that district. Districts 3 and 4 will be supplied with water from the high level booster pumping station at Cottingham Street as at present, drawing water from either of the two districts below. This pumping station in addition to the two new high level pumping stations can also supply the enlarged District 2 by drawing water from District 1 and will therefore also pump into the new 50 million gallon service reservoir. Thus the new works will supply water directly or indirectly at both ends and towards the middle of

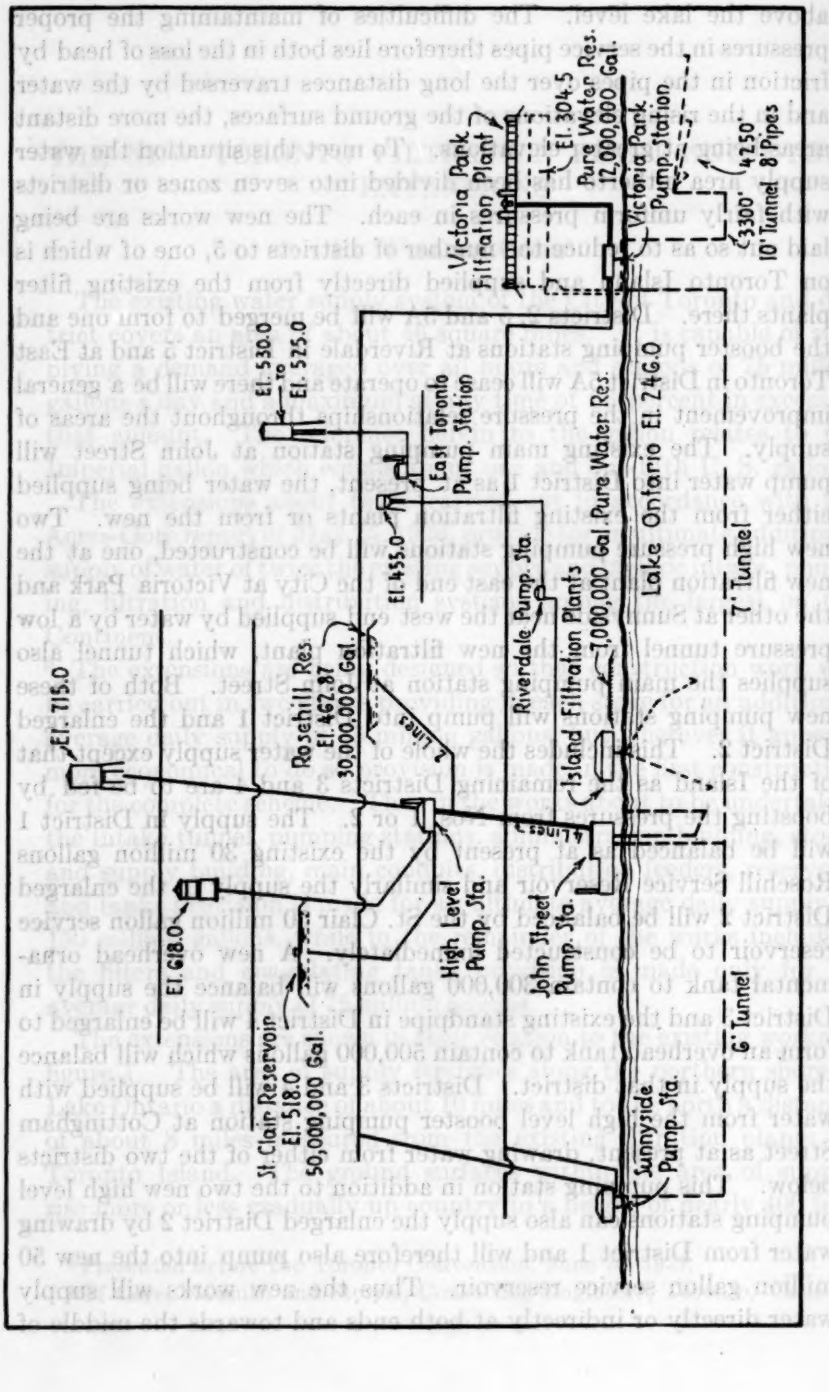


FIG. 1. TORONTO WATERWORKS—DIAGRAM SHOWING ELEVATIONS OF WATER DISTRICTS

both districts Nos. 1 and 2. The balancing reservoirs are nearly in the middle of their districts in an east and west direction, but outside to the north to secure higher elevations than exists within the districts. New high pressure feeder mains of 54-, 42-, 36- and 30-inch diameters of a total length of 15¾ miles will be constructed as well as the low pressure filtered water tunnel 7 feet in diameter to John Street Pumping Station and 6 feet in diameter in its continuation to Sunnyside Pumping Station, a total length of 9½ miles.

### INTAKE PIPES AND TUNNEL

The new intake is to be constructed just outside the east end of the City and leads diagonally out from the shore into Lake Ontario. It consists of an intake tunnel 10 feet in diameter, concrete or gunite lined, 3,300 feet long and three 8 feet pipes bedded in concrete extending out into Lake Ontario a further distance of 4,250 feet more or less. Only one of these pipes will be constructed immediately. The remaining two will be constructed as and when required and in the direction and length necessary to secure water as free from turbidity and pollution as possible, so as not to overload the filters when operating at standard rates. The position of the inlet to the first of the three intake pipes was determined after careful surveys had been made of the conditions to be met in the Lake due to contamination by the inevitable sewage, trade wastes and surface water drainage of a great city and the movements of the contaminated Lake waters due to wind driven currents. The site is where high cliffs abut upon the Lake and where the land drainage except for a very small area is away from the shore. The sewage contamination in the Lake generally moves along shore under the influence of variable winds, spreads east and west and gradually diffuses. It is naturally reduced the further you go outwards into the Lake and is mostly under the control of the City. Great improvements in dealing with the wastes of the City are to be anticipated in the immediate future. The prism of water between the new intake and the shore is much greater than in the case of the existing intakes and surveys indicate much better qualities of the raw waters. The intake proper will be of the submerged type constructed of steel with ring ports of very large areas at a point in the Lake where the minimum depth of water is about 52 feet.

The junction of the intake pipes with the intake tunnel is also submerged below the required minimum depth of 26 feet for shipping.

It consists of a closed shaft from the top of which the three steel pipes diverge. Each pipe is provided with a gatevalve which can be operated by a diver as and when required.

### VICTORIA PARK PUMPING STATION

At the shore end of the intake tunnel a shaft will be constructed which leads up into the suction well of a low lift pumping station containing electrically driven centrifugal pumps. The water will be passed through revolving screens and a surge overflow will be provided. High lift pumps for the two districts will also be conveniently grouped in the same building. Steam standby power is not being provided at this station. The hydro-electric power system from which power is to be taken is supplied by two power lines from Niagara and one from the Gatineau. The high pressure service reservoirs will contain 80 million gallons and the existing steam plant at John Street is capable of pumping at the rate of 102 million gallons per day, drawing water from the existing filtration plants which are provided with steam standby. Thus the risk of failure is well provided for.

### FILTER PLANT

The low lift pumps will deliver the water by duplicate conduits to the filter plant placed on the high ground above the cliff at the waters edge. At the standard rate of 105 million gallons per acre per day the 40 filters will deliver 200 million gallons per day. The filters will be of reinforced concrete placed in two rows on either side of a central gallery raised well above the filters. The filters are to be in two equal groups separated by a centre piece forming the main entrance. In this group are the administration offices, chemical and bacteriological laboratories, store rooms, men's quarters, two overhead wash water tanks, wash water pump room, blower room, chlorine and sulphur dioxide store, super-chlorination room, elevators and lavatories. The whole of the centre piece together with one group of filters will be constructed at the present time. The finished plant is being designed with a view to securing the highest efficiency in operation. The building of reinforced concrete faced with buff brick and coursed stone should be pleasing, lending itself to the unique nature of the site above a cliff overlooking Lake Ontario. The grounds will be suitably laid out and planted and provided with a protection wall and promenade at the waters edge. The principal floors of the

buildings will be laid to designs in terrazzo and a sparing use will be made of decorative marble in the main corridors and central octagonal hall. In the latter will be provided master gauges and clocks and signalling apparatus carried upon a neatly designed pedestal. The indicators will be such as to be clearly readable at distances up to 400 feet.

The laboratories occupy the upper floor of the main entrance portion of the centre piece and provide an area of 2,000 square feet. They are to be fully equipped with the necessary apparatus and staff for controlling and directing the purification operations. In this portion of the building are also the administration offices and store rooms for light articles. An elevator as well as stairs are provided for reaching the various floors and for access to a covered way or tunnel to the pumping station which will be at a level of 60 feet lower than the main floor of the filter house. The tunnel and elevator shaft also provide space for the smaller pipes and conduits passing between the pumping station and filter plant.

The filter plant conforms very closely to the standard practice in mechanical filtration in which the water is treated with filter alum or other coagulating substances. These substances will be supplied from dry feed machines in a separate group of buildings. In this building provision will also be made for machine and other shops, a garage and heavy stores.

Mixing tanks for one-half hours treatment and settling tanks for two hours and 50 minutes are provided for the maximum rate of flow. In order to determine the proper treatment an extensive series of mixing experiments was carried out by Howard and Sanderson at the existing works. It is possible that some form of colloider will be added which has been found recently elsewhere to be remarkably effective in securing settlement in the tanks where large quantities of floc would otherwise pass over into the filters.

### FILTERS

The filters, 40 in number, are each 68 feet by 35 feet 7 inches with a net sand area of 2103 square feet and filters slightly over 5 million gallons daily at standard rates. The raw water conduits and drains are at the extreme ends of the two rows of filters away from the gallery, while the wash water pipes and the filtered water channels are under the operating gallery. The underdrain system has been designed to avoid shock due to changing velocities and

quantities and to provide at each orifice a uniform delivery of wash water. The orifices are $\frac{3}{4}$-inch diameter of bronze, inclined downwards at 45 degrees away from the current in the pipes. The orifices are placed on 1 foot centres each way in graded gravel the top layer of 6 inches being cemented. The sand will be 30 inches in depth and will have an effective size of about 0.5 millimeter and a uniformity coefficient of about 1.5. The wash water troughs will be of reinforced concrete leading to a central main trough.

### PURE WATER RESERVOIR

A pure water reservoir of 12 million gallons will be placed under the filters, but its use for balancing the supply and demand will be restricted owing to the provisions for super-chlorination and subsequent dechlorination by sulphur dioxide. When such treatment is being adopted the pure water reservoir is used to hold the water under treatment for a minimum period of one hour and 20 minutes and must be maintained full. The filter controllers are to be arranged arbitrarily either to operate at a fixed rate or with a fixed back pressure and a maximum demand. The reservoir is laid out with division walls so that the water can be circulated. The filtered water will be collected, measured by venturi meters and treated with chlorine at the entry to the reservoir and will receive the sulphur dioxide a short distance before it reaches the outlet from whence it passes by duplicate conduits to the high level pumping station and pure water low pressure tunnel.

### FILTERED WATER TUNNEL

This tunnel will be 7 feet in diameter for a length of 30,993 feet from the filtration plant to the junction at John Street and 6 feet in diameter for a length of 18,198 feet from the junction point to Sunnyside and 6 feet in diameter for a length of 638 feet along the short branch to the John Street Pumping Station. The tunnel will be constructed wholly in the Lorraine shales with horizontal inverts about 100 feet below mean water level in Lake Ontario. Near John Street Pumping Station there will be a depression of 11 feet in the elevation of the tunnel in order that it may pass under the existing water works tunnel with a minimum distance of 25 feet between them. The depression will extend over a distance of about 2800 feet. Alternative bids are being asked for lining the tunnel either with concrete or gunite. The minimum cover of shale is estimated

from extensive borings to be about 25 feet, while the maximum is 110 feet. The minimum cover exclusive of water is about 85 and the maximum 135 feet.

In plan the tunnel will follow the mainland shore line and for the most part along highways or intended highways and very little private property will be entered. Eight permanent shafts are to be provided. The maximum distance between any two is about 11,000 feet. Two of these shafts, one at the termination of the short branch at John Street and the other at the terminal at Sunnyside will be provided with differential surge tanks 30 and 24 feet diameter respectively. The anticipated movements of the water in these interconnected surge tanks $3\frac{1}{2}$ miles apart form an intricate problem in hydraulics. The tunnels will provide for a delivery of 90 million gallons per day at the main pumping station at John Street and 50 million gallons per day at Sunnyside, while in addition provision is being made to deliver 60 million gallons per day from the high lift pumping station at the filtration plant, making the total 200 million gallons per day to be delivered by the filters.

The connection between the new tunnel and the existing pumping station at John Street has to be entirely independent of the existing supply as the two waters cannot be mixed prior to high lift pumping owing to the fact that the dechlorination by sulphur dioxide of the existing supply must be carried on in the suction channels of the high lift pumps at John Street. These pumps, however, have been laid out in two groups and it will be made possible for one group to draw from the existing sources and the other from the new.

### ST. CLAIR RESERVOIR

The new service reservoir will be 23 feet deep and will contain 50,000,000 gallons in two equal compartments. The supply will enter one compartment and circulate through a distant opening between the two compartments and be afterwards withdrawn from the second compartment. This will secure a circulation and change of the water and is provided by specially designed reversed check valves on the two branches to the two compartments from a common 54-inch steel pipe line coming up from the pipes in District 2 from the three pumping stations.

The reservoir will be of reinforced concrete covered with earth. The pipes to the reservoir are laid through the embankments in a tunnel which terminates at the reservoir in a valve house and ven-

tilation shaft. The tunnel portal has been featured architecturally and provides access both inside and out to the reservoir and grounds.

Very extensive provision has been made for both surface and underground drainage so as to secure stability of the structures and embankments. The reservoir has been made to conform to extensive improvements in roads and bridges in the vicinity and the grounds are to be laid out and planted for use as a public park.

To provide for contraction, joints in the walls and roof are made at distances not exceeding 60 feet. Water seals are provided in the joints by folded copper strips. In order to minimize the effects of initial contraction of the concrete and to prevent drying out the concrete, floors are to be placed after the walls and roofs are completed and separation strips of poured bitumen will be provided between each portion and around all columns.

## ORNAMENTAL OVERHEAD TANK

An overhead tank for District 3 will be placed at the site of the service reservoir. This tank will contain at normal water level 300,000 gallons and will have a freeboard of 10 feet to cover variations in pumping pressure. The tank will be constructed of steel surrounded with an ornamental casing of reinforced concrete faced with brick and coursed stone.

## COST

The estimated cost of the works to be constructed immediately is $14,317,000.

## PERSONNEL

The works are being carried out under the direction of R. C. Harris, Commissioner of Works, with G. G. Powell as Deputy. James Milne is in direct charge of waterworks, with A. U. Sanderson as assistant. H. G. Acres and Company, Limited, and Gore, Nasmith and Storrie are the Consulting Engineers.

# OPERATING EXPERIENCES WITH A LARGE FILTER PLANT[1]

By J. Clark Keith[2]

The purification plant operated by the Essex Border Utilities Commission has a nominal capacity of 21 million Imperial gallons per day. In one respect at least it is unusual, in that it is jointly owned by nine communities serving approximately 120,000 people. The capital costs were originally apportioned on the estimated consumption of each municipality five years hence. The operating costs are based on the actual amount of water delivered to each municipality. This is determined by meter measurement. The plant delivers water by gravity to two pumping stations, one privately owned by the Walkerville Water Company, which serves four communities, the other the municipal plant of the City of Windsor, which serves the other five. Details of this plant have previously been presented to this Association.

## INTAKE TROUBLES

The source of supply is in the Detroit River and is a typical Great Lakes water. The initial source of possible trouble in any plant is naturally at the intake. Due to the constant movement of ferries between the Candian and American shores, there is seldom an ice cover over the intake which is located in 40 feet of water about 1½ miles upstream from the ferry crossing. Under favorable conditions frazil ice develops which has adhered to the 8-foot bell mouth of the intake, causing partial or complete interruption of flow.

In designing the low lift pumping station, the possibility of such trouble was recognized, as it has occurred in other intakes along the Detroit River. The piping from the pumps was so arranged that pressure could be applied to the intake in the belief that the ice which had formed at the mouth could be blown off. Frazil ice has appeared in this intake on three separate occasions in such quantities as to

[1] Presented before the Toronto Convention, June 26, 1929.

[2] Chief Engineer, Essex Border Utilities Commission, Windsor, Ont., Can.

cause almost complete interruption of service. In each instance, immediate relief has been secured by reversing the flow in the intake. Large masses of ice conforming to the contour of the pipe would then come into the suction well. The average time required for the operation is twenty-five minutes, during which period the reservoir is being drawn upon.

Frazil ice did not appear during the past winter, although conditions, based on previous experience, were favorable for its formation. Continued cold, not common to this district, caused Lake St. Clair and the upper part of the Detroit River to freeze over and to remain covered with ice. This ice cover prevented the formation of frazil ice in that section of the river from which this supply is drawn.

The water entering the suction wells is comparatively free from the larger debris such as tree limbs, submerged logs, leaves and weeds and no great amount of these is removed by the revolving screens. Late in the autumn fairly heavy quantities of weeds find their way into the suction well. These are believed to be set free by the impellers of passing freighters. A half revolution per 8 hour shift is sufficient to keep them clean.

## APPLICATION OF CHEMICALS

The coagulants, fed from dry feed machines, are applied to the water at the entry to the suction wells and are mixed by the turbulent action of the water in the wells, the passage through the low lift pumps and in the "over and under" type mixing chambers at the entrances to the coagulation basins. Sulphate of aluminia is the principal coagulant and the dosage is determined by the quantity and the quality of the turbidity in the raw water. The dosages applied generally range from a minimum of 0.6 to a maximum of 3.5, with an average dosage of 0.89 g.p.g.

During the month of April, 1929, turbidities as high as 800 p.p.m. were recorded. The average for the month was 175, which is the highest monthly average noted since the opening of the plant three years ago. To reduce these turbidities to a maximum of 40 in the applied water and to maintain an effluent of less than 1.0 p.p.m. alum dosages from 20 to 80 percent in excess of the scheduled dosages were applied. During one twenty-four hour period it was necessary to apply 5 g.p.g. to a raw turbidity of 275 p.p.m. to produce a satisfactory effluent.

These unusual turbidities are believed to arise from the high water

now prevailing in Lake St. Clair. Silt and sand have been accumulating on the shores for years and these have been brought into suspension by the change in lake levels. Lake St. Clair is, relatively speaking, so shallow that even a moderate wind disturbs the entire lake body.

### EXPERIENCE WITH IRON AND LIME

Ferrous sulphate and hydrated lime were introduced as coagulants in May, 1928, in an effort to increase the length of filter runs during the "algae" period. During the month of June, 1927, it became necessary to backwash filters every one and one-half hours as a result of the high plankton content of the raw water. This affected the quality of the effluent and the delivering capacity of the plant to such an extent that a remedy was sought to better plant operation during that period.

Dosages ranging from 2.4 to 2.0 g.p.g. iron and 1.8 to 1.0 g.p.g. lime were fed and satisfactory results were obtained in all cases. The maximum dosage represented a cost 2.75 times that of the scheduled alum dosage while the minimum dosage cost 1.6 times as much. The lime and iron were fed separately from two dry feed machines ordinarily used for lime. We learned by experience that they could not be fed from the same machine as in combination they formed sulphate of iron within the hopper. It was necessary to add small paddle wheels to the machine delivering lime to prevent arching over. Sulphate of alumina cost $26.20, hydrated lime, $14.00 and sulphate of iron, $21.00 per ton, all delivered at the plant.

During the period when lime an iron were employed as coagulants, the following conclusions were reached or results attained:

(*a*) The service hours of the filters were extended to a minimum of ten hours.

(*b*) The effluent did not suffer physically, having at all times less than 0.5 p.p.m. of turbidity.

(*c*) The filter mat showed less signs of shrinkage and cracking than was observed during the "algae" period of 1927.

(*d*) Lime and iron required approximately 15 percent more wash water per million gallons filtered than was required with alum, when length of run and turbidities were equal.

(*e*) An increase in the turbidity of the raw water above 25 p.p.m. could be met with a decrease in the quantities of coagulants used.

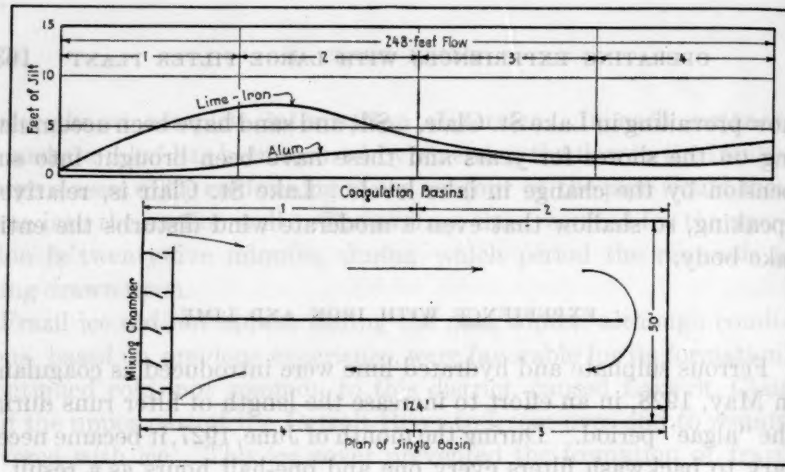
248-feet Flow
Feet of Silt
Lime - Iron
Alum
Coagulation Basins
Mixing Chamber
30'
124'
Plan of Single Basin

FIG. 1

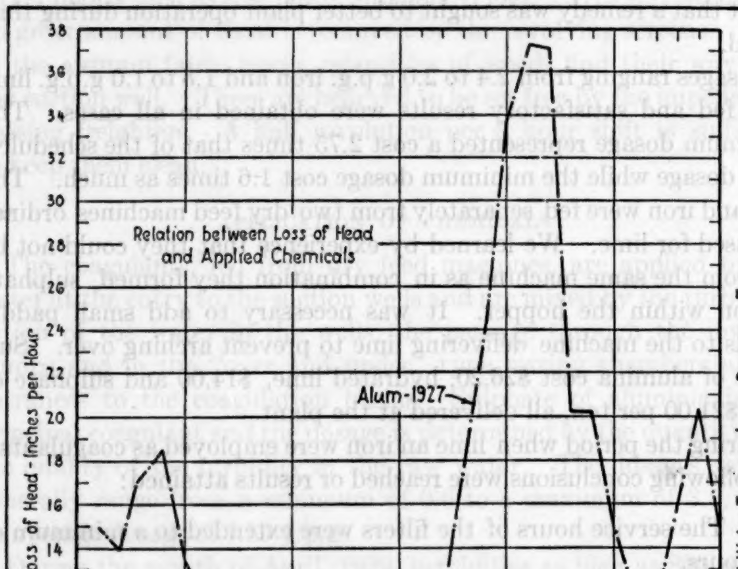
Relation between Loss of Head and Applied Chemicals
Alum-1927
Lime-Iron-1928
Air
Water
Loss of Head - Inches per Hour
Air and Water Temperature - Degrees F.
June 1927-1928

FIG. 2

(*f*) The results obtained justified the added cost and the use of lime and iron in the "algae" period will be continued.

It will be noted in figure 1 that the point of maximum settling with alum as the coagulant, occurs at the end of the second quarter over the distance travelled in the settling basins, while with lime and iron this point is reached just past the end of the first quarter.

Figure 2 compares the loss of head in inches per hour during June, 1927, with sulphate of alumina as the coagulant, with that experienced in June, 1928, when lime and iron replaced alum. The

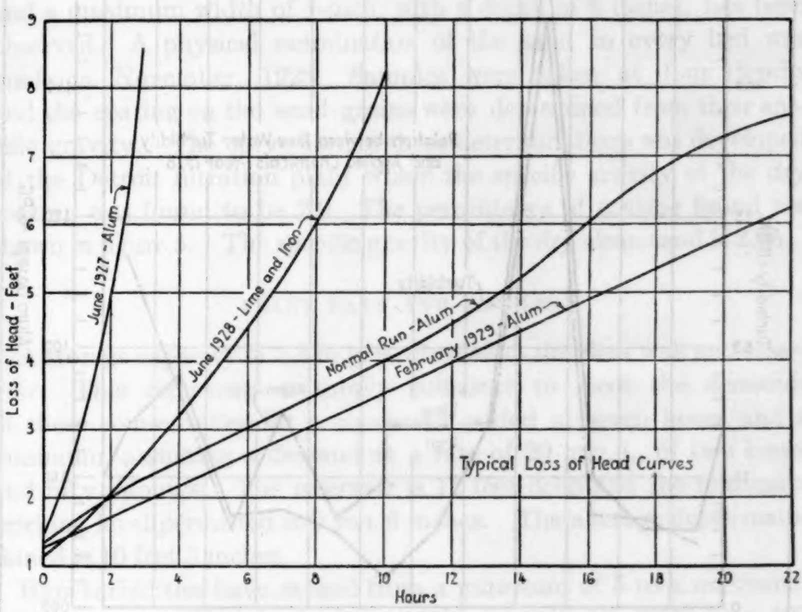


FIG. 3

maximum loss of head per hour with alum was 36 inches while with lime and iron this was reduced to 9 inches.

Typical loss of head curves obtained with the two coagulants are shown in figure 3.

The relationship between the turbidity of the raw water and the applied dosages of alum is shown in figure 4. In the month of December, the lines diverge due to the presence of very finely divided particles in the raw water with a heavy increase in alum dosage. This followed directly the autumn turnover of the lakes. During Febru-

ary the water is so free of turbidity that it would be satisfactory without filtration.

The period of retention in the coagulation basins ranges from one and one-half to four hours, depending upon the demand. The basins are cleaned twice yearly, following the spring algae period and again in the late autumn. Normal procedure permits the draining, cleaning and refilling of a single basin in ten hours.

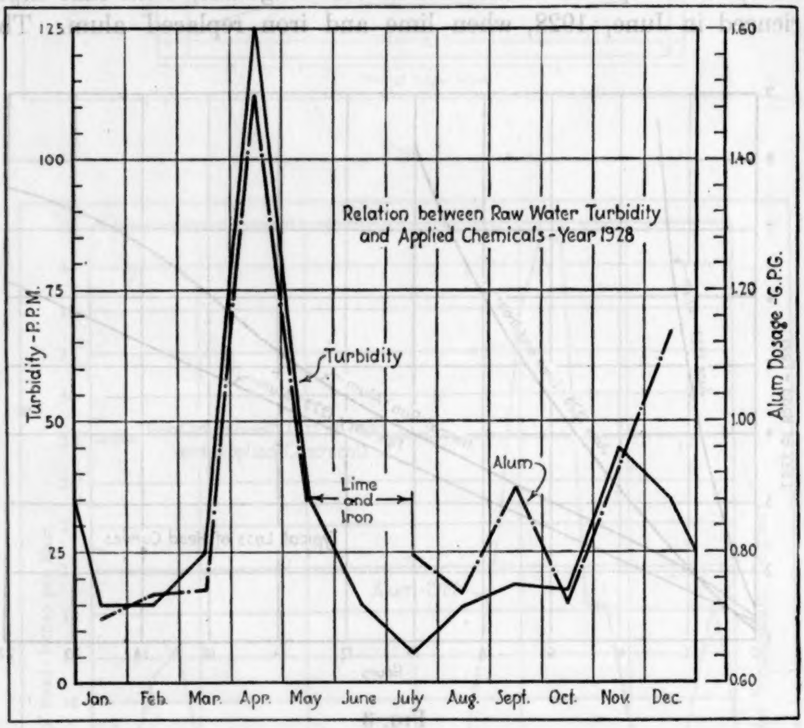


FIG. 4

## MUDBALLS AND SAND BED SHRINKAGE

Mudballs appeared shortly after the opening of the plant. On examination it was found that a large portion of them had formed with a cotton seed as the nucleus. This seed had apparently been in the car in which the filter sand was loaded. Others were flat or almond shaped. The former was found to a depth of 20 inches in the sand, while the latter remained on the top of the bed. They were removed by fishing the beds with wire mesh scoops while wash water

was applied at a rate just sufficient to expand the sand. Their appearance was not noted again, to any extent, until November, 1928, when, following a period of slimy turbidity, they were found in all beds. Extra backwashing and fishing with the wire mesh scoops kept them under control and they disappeared early in December. These formations have never been larger than a good sized bean and have been in evidence only twice in three years.

Some shrinkage from the side and end walls has been observed. The average width of the crack is $\frac{3}{8}$-inch and it reached a depth of 2 to 3 inches. During the spring algae periods, this shrinkage increases and a maximum width of $\frac{3}{4}$-inch, with a depth of 6 inches, has been observed. A physical examination of the sand in every bed was made in November, 1928. Samples were taken at four depths and the coating on the sand grains were determined from their specific gravity. The curve used in these determinations was developed at the Detroit filtration plant where the specific gravity of the dry coating was found to be 2.0 The percentages of coating found are shown in figure 5. The specific gravity of the dry clean sand is 2.65.

## PLANT DATA AND RESULTS

A storage capacity of 2.3 m.g. is afforded in the clear well and reservoir. This represents a supply sufficient to meet the demands of these communities for a maximum period of seven hours and a minimum, assuming a demand at a rate of 20 m.g.d., of two hours and fifty minutes. The reservoir is 11 feet deep and the minimum working level permitted is 9 feet 6 inches. The average depth maintained is 10 feet 3 inches.

Raw turbidities have ranged from a minimum of 5 to a maximum of 800 p.p.m. The maximum monthly average in 1928 was 125 and the average for the year was 30 p.p.m. The filtered water is checked for turbidity at least six times daily, using a Baylis turbidimeter. A maximum of 1.0 was present for a few days in 1928 in the effluent, while the average recorded was 0.3 p.p.m.

The rate of flow through the filter beds is governed by three factors: The demand upon the plant, the filtering efficiency of the beds and the filter maintenance program. A filter rate is maintained which will bring all beds into service during the peak hours of the day. Rates are not changed daily. The rates employed in 1928, expressed in terms of millions of Imperial gallons per acre per day, ranged from

a minimum of 99.6 to a maximum of 118.5, with an average throughout the year of 112.07.

Laboratory control is exercised over all operations in the plant. The raw and applied waters are examined for turbidity every two hours and the alum dosage changed as required.

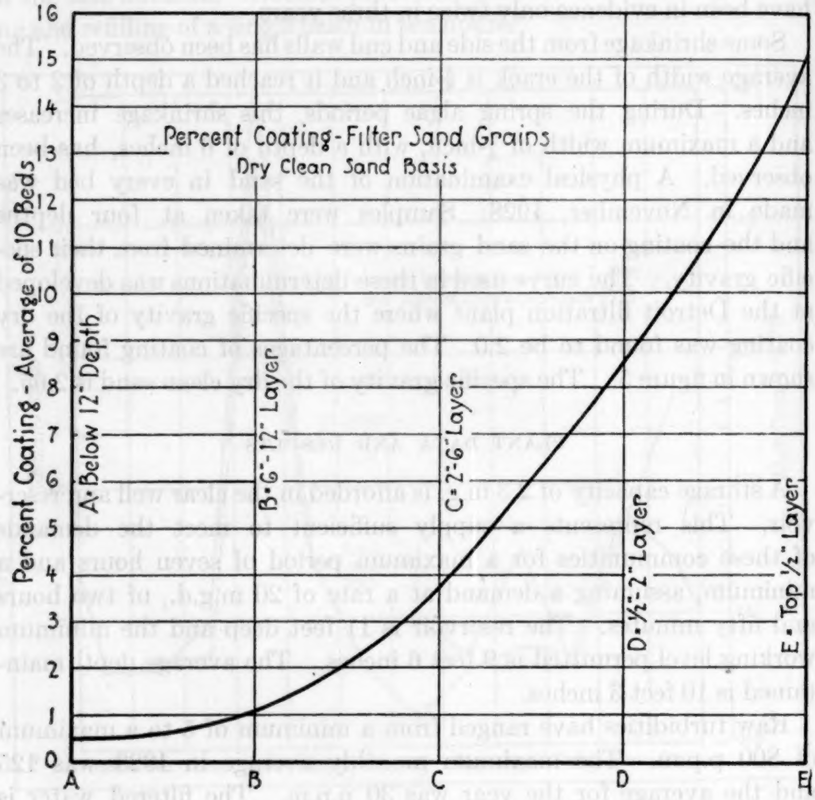


FIG. 5

Samples of raw and filtered water are collected 5 times daily for bacteriological analysis and colony counts are recorded which develop on agar plates at 37°C. in twenty-four hours. The average raw water developed 39 and the filtered water 6 colonies per cc., showing a removal of 85 percent B. coli-aerogenes isolations are made following "Standard Method" procedure, using lactose broth fermentation tubes and eosine methylene agar for confirmation. The results are

expressed in term of "Most probable number per 100 cc." The maximum B. coli content of the raw water has occurred in April, when 117 colonies per 100 cc. were found. A minimum of 4.99 was recorded in June, while the average for 1928 was 50. The average number found in the filtered water was 1.59, with a maximum of 2.39 and a minimum of 0.98, with an average removal of 96.8 percent.

Air and water temperatures are recorded every two hours and the wind direction is noted at these times. The velocity and direction of the wind have a definite bearing on raw water turbidities during the spring, summer and autumn seasons. It is thus possible to anticipate plant conditions some hours in advance.

Early in 1929 daily examinations of the raw water were begun to determine plankton content. It is expected that a relationship between these findings and the service hours of the filters will be ascertained when sufficient records are available for study. This will provide additional means of determining coagulant dosages. In the three months period in which these examinations have been made, no members of the plankton families, not common in the Great Lakes water, have been identified. Microcystis (Cyanophyceae) appear frequently and represent from 20 to 50 percent of the total daily counts.

Daily records are kept of every operation carried on in the various departments of the filtration plant. In the low lift pumping station the rate at which the raw water is being pumped to the coagulation basins and the total gallons pumped are recorded each hour. The total gallons of wash water delivered to the filter beds are also recorded. The power used by the various pumping units and the total power consumption of the plant is recorded once daily. The total hours in service of every unit in the pumping station are logged on the daily report form.

In the filter building all meters, loss of head and rate of flow gauges are read and recorded every hour. The depth of water in the filtered water reservoir is recorded hourly. These daily records are summarized each month and they in turn are built into an annual report. A plant diary provides a permanent record of items of ordinary or unusual interest and constitute a permanent plant history. All gauges and indicating or recording devices are kept in working order at all times and the utmost care is taken to ensure knowledge, if not control, of every operation attempted. One employee is constantly engaged on plant maintenance and it is rarely necessary to place any unit out of service except for inspection or maintenance.

COST DATA

The plant is electrically operated with power supplied by the Hydro Electric Power Commission of Ontario. The rates are $1.00 per H.P. per month based on the peak load, 2¼ cents per kilowatt for the first fifty hours, 1⅓ for the second fifty hours and 0.33 cent for all additional power.

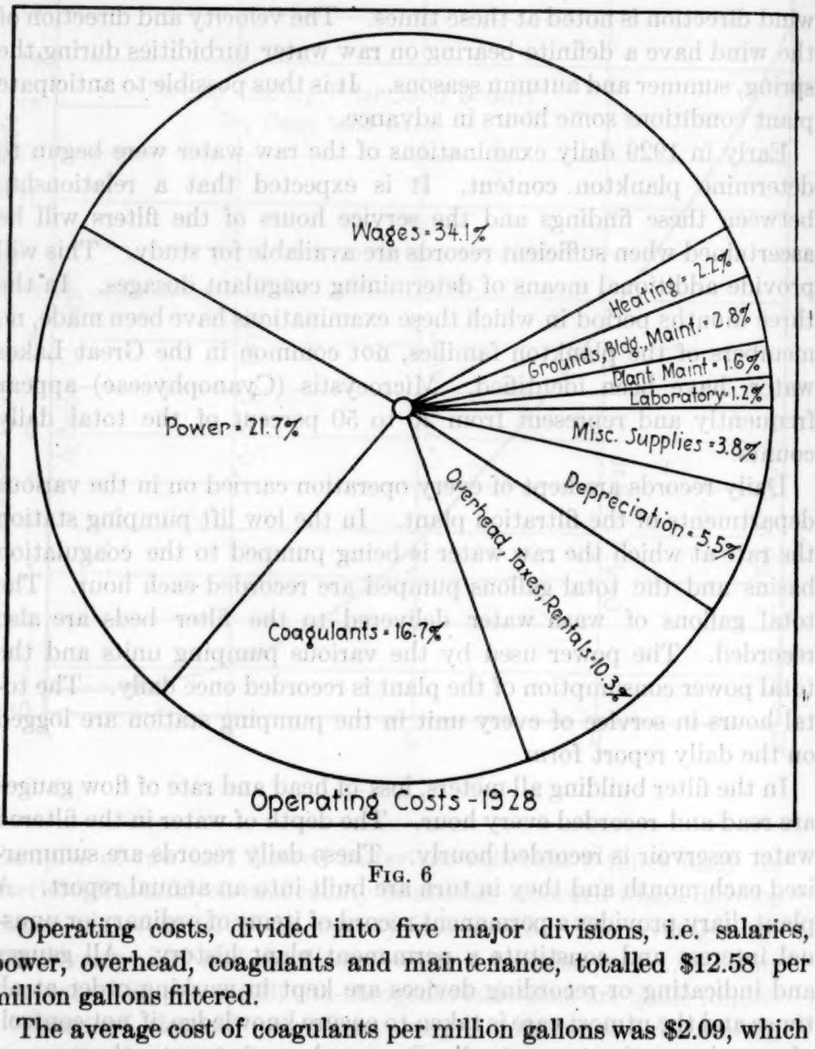


Fig. 6

Operating costs, divided into five major divisions, i.e. salaries, power, overhead, coagulants and maintenance, totalled $12.58 per million gallons filtered.

The average cost of coagulants per million gallons was $2.09, which included the added cost of lime and iron coagulation. During the period when lime and iron coagulation was employed, the average

cost per million gallons was $4.09. Alum coagulation during the balance of the year represented an average charge of $.171 per million gallons filtered.

Salaries represented $4.28 of this sum, power $2.74, overhead $2.33, coagulants $2.09 and maintenance $1.24. These costs are shown on figure 6.

The operating staff includes a superintendent, a chief operating engineer, a chief filter operator, three operating engineers, two filter operators and a utility man. The lowest wage paid is 62½ cents per hour.

The total power consumption for 1928 was 1,455,000 kilowatt hour, costing an average of 0.82 cents per kilowatt hour. The pumping cost for power alone, exclusive of wash water, averages $2.55 per million gallons or 6.7 cents to raise one million gallon one foot.

Overhead charges include supervision, rentals paid for use of railway right-of-way, taxes and insurance. A depreciation reserve of $3,000 is set aside annually to replace the heating system, motors and pumps which will need replacement within the thirty-year life of the debentures.

Maintenance charges include the general upkeep of machinery, buildings and grounds and the purchase of miscellaneous supplies required in this work. The grounds are attractively maintained as water works plants should be.

Acknowledgment is made to G. H. Strickland, plant superintendent, for much of the information contained in this paper.

# COMPARATIVE DATA ON STEAM AND ELECTRIC PUMPING STATIONS[1]

By J. F. Laboon[2]

Electric power is becoming increasingly popular for pumping station use, and deservedly so, especially in localities where super-power is available. Electric driven units are low in first cost, convenient of operation, labor saving, and saving of space. Where power is available from at least two dependable sources to satisfy Underwriter requirements and reservoir storage is provided, motor driven pumps become even more desirable as fire insurance rates remain unaffected and economical operation is possible by maintaining the units at their rated capacities. However, if reservoir or standpipe storage is not available, thus necessitating pumping directly into the distribution system, motor driven centrifugal pumps become less efficient and consequently less desirable. This is in contrast to direct acting steam pumps which can be governed automatically to maintain pressure requirements at varying outputs without material sacrifice of efficiency. With conditions favorable to the use of motor driven units, the cost of power then comes into consideration.

Comparisons of costs as between steam and electrically driven stations, including gas and oil where available at reasonable prices, are usually made in determining the most economical kind of power. A case in point is that of Wheeling, W. Va., where electric power supplanted steam, although coal was mined practically at the front door of the boiler house. The comparative costs of steam and electrical stations are given in table 1.

The costs for the electrical station are taken from the records for the year 1928, while those for the steam station have been closely estimated. Production is assumed at 15 million gallons per day, although the station has a rated capacity of 20 million gallons per day, and the actual consumption for 1928 was 12.8 million gallons

[1] Presented before the Toronto Convention, June 25, 1929.

[2] Consulting Engineer, Pittsburgh, Pa.

TABLE 1

*Comparison of pumping costs at Wheeling, West Virginia*

| | |
|---|---|
| **Actual cost of electric station** | |
| Railroad siding (proportioned) | $1,100 |
| Pumping station complete | 281,624 |
| Construction cost | $282,724 |
| Engineering and contingencies | 27,276 |
| Total | $310,000 |
| **Estimated cost of steam station** | |
| Railroad siding (proportioned) | $2,500 |
| Wet well and screens | 30,000 |
| Pumps | 181,000 |
| Pump station buildings | 130,000 |
| Piping connections | 20,000 |
| Boiler plant | 186,000 |
| Engineering and contingencies | $549,500 |
| | 54,500 |
| Total | $604,000 |
| **Fixed charges and operating expenses for 15 m.g.d. production** | |
| *Electric station:* | |
| Fixed charges—interest and depreciation | $23,000 |
| Power at $0.00859 per kilowatt hour | 70,700 |
| Labor | 13,100 |
| Oil, maintenance, etc. | 7,075 |
| Total | $113,875 |
| Pumping cost per million gallons | $20.80 |
| *Steam station:* | |
| Fixed charges—interest and depreciation | $45,000 |
| Coal at $2.75 | 27,500 |
| Labor | 50,500 |
| Oil, maintenance, etc. | 10,000 |
| Total | $133,000 |
| Estimated pumping cost per million gallons | $24.30 |

TABLE

*Nashville, Tenn.—Steam Station operating data*

Percentage of time run

| PUMPS | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Worth. No. 1, H.S. | 2.4 | 0.6 | Dismantled | | | | | | | | |
| Worth. No. 2, H.S. | 0.4 | 0.5 | 0.3 | Dismantled | | | | | | | |
| Holly, H.S. | 1.9 | 0.3 | 0.2 | 0.3 | 0.04 | | | | Dismantled | | |
| Allis, H.S. | 95 | 99 | 97 | 79.5 | 32 | 4.9 | 20.6 | 12.7 | 19.4 | | |
| H.S. turbine and L.S. uniflows | | | | 17.3 | 66 | 93 | 78 | 86.6 | 80.6 | | |
| Electric, L.S. and H.S. | | | | | | | | 12.5 | 12.2 | | |
| Pumpage, M.G.D. | 13.6 | 14 | 14.9 | 15.1 | 15.6 | 16 | 16.1 | 17.6 | 18.8 | | |
| Coal, tons | 9,424 | 9,149 | 10,280 | 10,967 | 11,698 | 15,954 | 14,950 | 14,635 | 14,153 | | |
| Station duty, million foot pounds per 100 pounds coal | 71 | 78 | 73.5 | 73 | 70.5 | 54.5 | 58 | 62 | 70.3 | | |
| Cost coal per ton | 4.70 | 4.20 | 4.05 | 3.62 | 3.96 | 3 | 2.73 | 2.91 | 2.75 | | |
| Gallons per foot head per pound coal | 85,800 | 94,000 | 88,200 | 87,700 | 84,800 | 63,500 | 69,700 | 74,600 | 84,900 | | |

per day. Steam pumping would cost 17 percent more per million gallons than electrical pumping according to this comparison. A comparison based on actual present day consumption would be even more favorable to electrical pumping. Power is furnished the city water works under a special municipal tariff based on a guaranteed load factor specified at the beginning of the year, which gives an average power cost of 8.59 mills per kilowatt hour. Slip ring motors were used in conjunction with a synchronous condenser to maintain unity power factor.

Nashville, Tenn., has been rehabilitating its water works for the past seven years, placing into operation in September, 1927, a new boiler house, boilers and auxiliaries. Electrically driven pumps have been installed since 1926 to augment the pumping capacity. Table 2 shows the results obtained under various conditions of steam pumpage, that is, with the old station operating a vertical triple expansion pump with one lift from the river to the storage reservoir; the improved pumping station with two horizontal uniflow engines operating vertical centrifugal pumps for low service, and a turbine driven centrifugal pump on high service; and later with the new boiler plant in operation. The motor driven centrifugal pumps are too recently installed to permit of any direct comparative data.

It will be noted that the station duty dropped off with two stage pumpage with the uniflow and turbine driven centrifugals in operation, but that this duty was materially improved upon installation of the modern boiler plant. Actual costs of operation have been omitted inasmuch as direct comparison of such costs with those of a similar plant might be productive of confusion, rather than good, since labor conditions and rates together with fixed charges vary with local conditions. Therefore, station duties instead have been given as a measure of economy.

Some direct comparison, however, can be made between the Nashville, Tenn., and the Erie, Pa., plants inasmuch as both involve in many respects the same types of pumps and conditions. Table 3 shows station duties and conditions of pumpage at Erie. In this case, too, it will be seen that economies were depressed as soon as the turbine driven centrifugal was put to protracted use, such as was the case in 1926 and 1927.

In computing station duties, the motor driven units are not included. Their function in the table is to show the proportionate use that is made of the various pumps, or types of power.

TABLE 3

*Erie, Pa.—Steam Station data*

Percentage of water pumped

| PUMPS | 1919 | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steam pumps..... | 100 | 100 | 100 | 100 | 100 | 100 | 96 | 76 | 78 | 90 | | |
| Electric pumps.... | | | | | | | 4 | 24 | 22 | 10 | | |
| Pumpage, total... | 20.4 | 21.7 | 19.6 | 20.5 | 22.7 | 22.2 | 24 | 24.7 | 24.1 | 24.1 | | |
| Pumpage, electric. | | | | | | | 1 | 5.9 | 5.4 | 2.3 | | |
| Coal, tons........ | 17,860 | 18,095 | 15,434 | 5,013 | 16,406 | 15,905 | 16,234 | 13,248 | 12,242 | 12,859 | | |
| Station duty...... | | 60.5 | 66.2 | 73.8 | 73.1 | 72 | 78.2 | 62 | 65.7 | 74.4 | | |
| Cost coal per ton.. | 3.51 | 6.61 | 4.15 | 5.09 | 3.88 | 3.37 | 3.20 | 3.07 | 3.68 | 2.95 | | |
| Cost of power per K.W.H......... | | | | | | | | 1.1 | 0.99 | 1.13 | | |
| At main station... | | | | | | | | | | | | |
| Gallons per foot head per pound coal............ | | 72,800 | 79,600 | 88,800 | 88,000 | 86,700 | 94,000 | 74,500 | 79,200 | 90,000 | | |

The Erie plant offers some direct comparison between costs of steam and electric driven units inasmuch as a 12 million gallon motor driven high service unit was installed in 1925 to augment the vertical triple expansion and the rest of the direct acting steam units. Comparative costs of steam and electric power pumping at the main station are shown in table 4.

TABLE 4

*Erie, Pa.—Cost of operating high duty pumps, foot of Chestnut Street, for year ending December 31, 1927*

| | STEAM POWER | ELECTRIC POWER | TOTAL | COST PER MILLION GALLONS |
|---|---|---|---|---|
| Superintendent, chief operator and clerk | $3,910.43 | $454.25 | $4,364.68 | $0.496 |
| Operating labor | 7,640.64 | 883.42 | 8,524.06 | 0.970 |
| Steam for engines 5, 6, 7 | 59,263.09 | | 59,263.09 | 6,740 |
| Steam for miscellaneous equipment | 3,885.18 | 204.49 | 4,089.67 | 0.465 |
| Electric power purchased Engine no. 8 | | 29,239.06 | 29,239.06 | 3.326 |
| Lubricants and waste | 415.14 | 0.70 | 415.84 | 0.047 |
| Electric light and power produced | 1,280.11 | 67.39 | 1,347.50 | 0.153 |
| Other supplies and expenses | 523.05 | 27.52 | 550.57 | 0.063 |
| Repairs and maintenance: | | | | |
| Buildings | 3,784.71 | 199.18 | 3,983.89 | 0.453 |
| Engines and attachments | 10,234.37 | 311.02 | 10,545.39 | 1.200 |
| Miscellaneous equipment | 442.44 | 23.30 | 465.74 | 0.053 |
| Depreciation | 12,776.57 | 2,842.68 | 15,619.25 | 1.777 |
| Total cost | $104,155.73 | $34,253.01 | $138,408.74 | $15.743 |
| Head, in feet | 257.5 | 359 | | |
| Pumpage, in gallons | 6,837,339,600 | 1,955,030,000 | 8,792,369,600 | |
| Foot pounds per dollar | 140,902,300 | 170,799,260 | | |

Average rate per kilowatt hour—0.99223 cent.

In allocating charges for depreciation, the electric unit has been charged with the proportionate space it occupies in the station and labor required for operation. Power is purchased on a regular tariff basis. Electrical pumping in this case is justified by virtue of

its economy. The difference in heads is due to the use of the electrical unit on booster service head, but this difference has been wiped out by the installation of a new booster station. The impeller of the 12 m.g.d. electrical unit has been cut back to permit of greater efficiencies at the reduced head under which the pump operates now. The pump was out of service for six months in 1928, pending the change in the impeller. Therefore, the pumpage by this unit was only 10 percent of the total during that year as shown in table 4.

TABLE 5

*Erie, Pa.—Cost of operating electric pumps, Booster Station, 26th and Sigsbee for year 1928*

| | |
|---|---|
| Superintendent and clerk | $832.00 |
| Operating labor | 3,793.06 |
| Electric power | 11,366.42 |
| Oil and waste | 4.25 |
| Maintenance and repairs: | |
| Pumps and motors | 402.86 |
| Miscellaneous equipment | 166.93 |
| Buildings | 304.51 |
| Heating and lighting | 255.77 |
| Miscellaneous supplies and expense | 162.49 |
| Depreciation | 1,759.44 |
| Cost of boosting 1,901,445,500 gallons or 5.2 m.g.d. from low service mains at 26th and Sigsbee to high service reservoir, a head of 96.2 feet | $19,083.73 |
| Cost per million gallons boosted | 10.036 |
| Foot pounds per dollar of cost | 79,700,000 |

Average rate of power per kilowatt hour—1.337 cents.

A new booster station consisting of two 5 m.g.d. and one 8 m.g.d. motor driven units has been completed to relieve the head conditions at the old station. This station has been in operation since December 1927.

Costs and economies are given in table 5 for the new booster station, electrically operated, for the year 1928.

Power for this station is costlier than that for the electrical pump at the main station, and this coupled with low head pumpage, combine to reduce economies somewhat below those found for the 12 m.g.d. unit at the main station. It is of interest to note that the

TABLE 6

*Pumping costs at Fostoria, Ohio*

| | |
|---|---|
| **Actual cost of steam equipment** | |
| 3 m.g.d. cross compound pump | $23,500 |
| Pump foundations and building | 8,200 |
| Two (2) 3 m.g.d. engine driven L.S. pumps | 4,100 |
| Foundations | 500 |
| Water and steam piping | 9,300 |
| | $45,600 |
| Engineering and contingencies | 4,400 |
| Total | $50,000 |
| **Estimated cost of electrical equipment** | |
| 6 H.S. and L.S. pumps installed | $9,000 |
| Foundations | 1,000 |
| Piping | 7,000 |
| Improvements to pump room | 2,000 |
| | $19,000 |
| Engineering and contingencies | 2,000 |
| Total | $21,000 |
| **Annual fixed charges and operating expenses—2 m.g.d. production** | |
| *Steam:* | |
| Interest and depreciation | $4,000 |
| Oil, maintenance, etc. | 500 |
| Coal | 4,000 |
| Total | $8,500 |
| Cost per million gallons | $11.60 |
| *Electric:* | |
| Interest and depreciation | $2,000 |
| Maintenance | 300 |
| Power | 14,000 |
| Total | $16,300 |
| Cost per million gallons | $22.50 |

new 16 m.g.d. pumping station and filtration plant now being designed for Erie, as an additional supply, will be electrically operated. In contrast to the trend towards electrical pumping units as exemplified in the preceding paragraphs, is the case of the pumping station at Fostoria, Ohio, where a study developed that it was more economical to install a cross-compound steam pump than an electrically driven centrifugal pump for high service. Table 6 gives the details of the comparison of costs as between steam and electrically driven pumping stations.

Power costs were computed from the regular tariff in force at the time. No saving in labor can be made with electrically driven units since the steam plant including boilers and pumps has been operated by one man per shift. New boilers were installed in 1925, so there was no need of improvement in the boiler plant, and no charge is made on this account in the comparative statement. It is interesting to note in this case that the total cost per million gallons pumped with steam equipment was approximately one-half of that for the electrical equipment. The steam station improvements were finally installed.

A few days ago the water department engineers of the City of Pittsburgh decided to electrify one of its largest stations, which will have a capacity of 80 million gallons per day. Current is estimated as costing 6.5 mills per kilowatt hour.

While increasing use is being made of electrical power for actuating pumping machinery, fundamental principles still hold good and must be applied to every situation where the question of improving the pumping station comes up, in order that a sound decision may be made.

# MECHANICAL DEVELOPMENTS IN WATER TREATMENT PRACTICE[1]

By C. T. Leander[2]

In the contemporary municipal and industrial water treatment practice, mechanical equipment is being used to a greater extent every year. The equipment offered to waterworks engineers is approaching standardization to an extent which permits a judicious selection of recognized machinery for carrying out the unit operations met to a lesser or greater degree in all water treatment plants. The infiltration of the unit process idea is widespread and almost any type of treatment may be broken up into a group of interconnected unit operations such as aeration, presedimentation, chemical coagulation and (or) chemical softening, sedimentation, filtration, chlorination, etc.

The present discussion will be confined to the unit operations of presedimentation, sedimentation, chemical softening and chemical coagulation in their relationship to each other, and to other unit operations in several typical flowsheets which have been found effective in three treatment problems frequently encountered. While these flowsheets have individually been discussed widely before by designers and operators of plants, they have not been discussed collectively in order to show their range of application and the considerations governing their selection in a given case.

The mechanical equipment for carrying out these unit operations which we are qualified to discuss, are the Dorr Traction Clarifier and the Dorr Impeller Agitator. The Dorr Traction Clarifier, as shown in figure 1, is a continuously cleaned sedimentation basin which, when receiving as its feed raw or chemically dosed water introduced through submerged ports along the influent side, overflows continuously a clarified water across a weir at the effluent side opposite and discharges a thick sludge from a bottom connection. It operates continuously, is never shut down for manual cleaning and duplicate or

[1] Presented before the Toronto Convention, June 28, 1929.

[2] Branch Manager, The Dorr Company, Toronto, Can.

stand-by units are not needed. The total tank contents are at all times available for detention purposes as sludge is removed at the rate of deposition.

The old device which it displaces is the well known settling basin, rectangular in shape and constructed of concrete and masonry. The difficulties attending their operation and cleaning used to be regarded as the necessary evils attending waterworks practice, for duplicate units and frequent cleanings were the order of the day lest the rapid

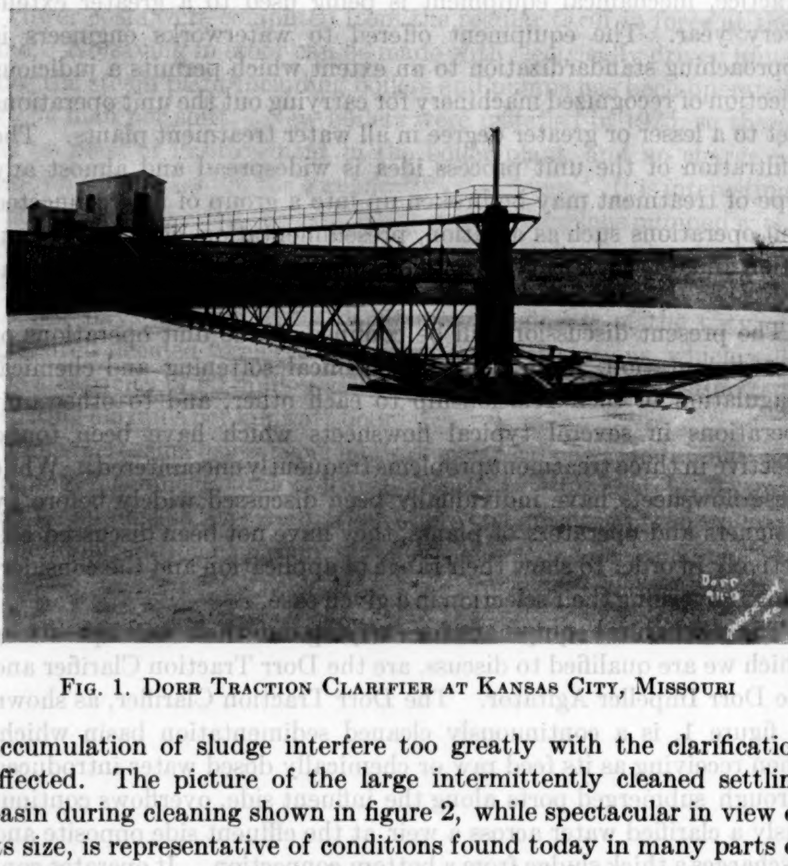

FIG. 1. DORR TRACTION CLARIFIER AT KANSAS CITY, MISSOURI

accumulation of sludge interfere too greatly with the clarification effected. The picture of the large intermittently cleaned settling basin during cleaning shown in figure 2, while spectacular in view of its size, is representative of conditions found today in many parts of the country. As will be shown later, several of the cities which built these basins have installed Traction Clarifiers in their new water works.

The Dorr Impeller Agitator was developed to satisfy the conditions prevailing in water treatment, that is, effective turnover of the raw

water to give homogeneity throughout but at a velocity at which flocs will form and build up rapidly. A cross section through such an agitator is shown in figure 3. A slowly revolving marine impeller in a cylindrical draft tube induces a gentle circulating motion of tank contents, upward through the tube and downward in the annular space surrounding it. A velocity between 0.5 and 1.5 feet per second is maintained as at this velocity floc builds up readily, yet does not settle on the tank bottom. In order to insure complete

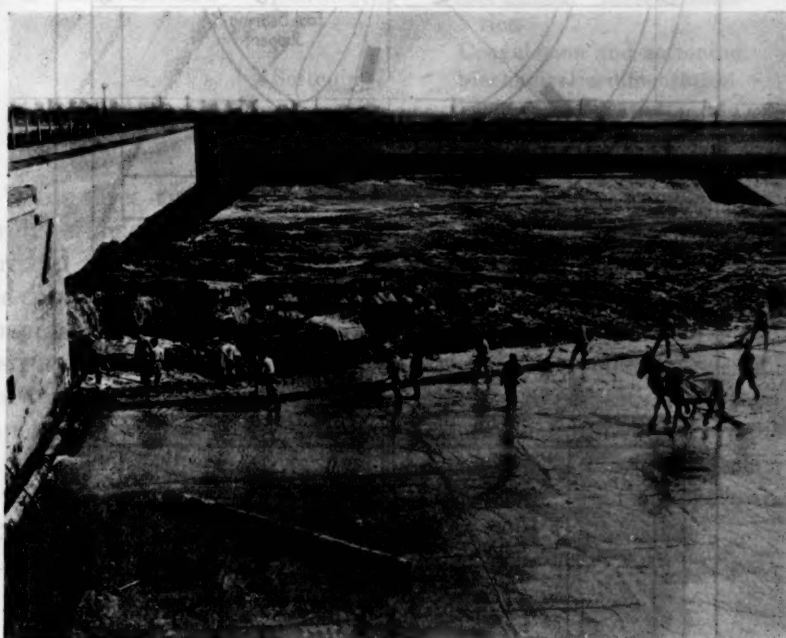

FIG. 2. PLAIN SETTLING BASINS FULL OF SLUDGE

treatment of all the water with a minimum of short circuiting, two or three agitator tanks, arranged in series, are recommended. Vertical baffles, at right angles to the flow line between influent and effluent ports, and extending from the bottom to slightly above the water level, minimize swirling and cause all of the water to pass through the draft tube several times.

With this brief outline of the salient features of the Clarifier and Agitator, consideration may be given to the development of flowsheets for handling the following three common problems.

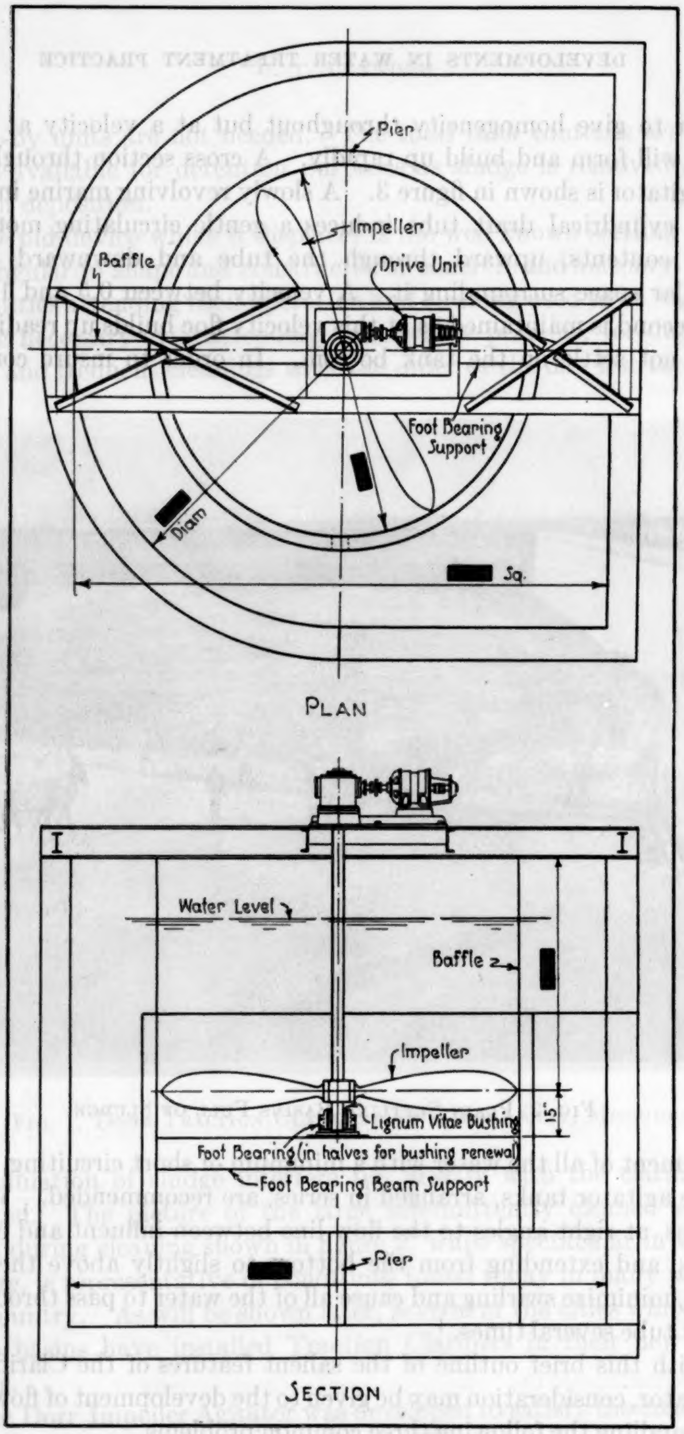


**Fig. 3. Diagram of Dorr Impeller Agitator**

| *Character of raw water* | *Treatment* | *Chief unit operations* |
|---|---|---|
| 1. Turbid and soft | Clarification | Coagulation<br>Mechanical sedimentation<br>(Plain sedimentation)<br>Filtration |
| 2. Clear and hard | Softening | Softening<br>Mechanical sedimentation<br>Plain sedimentation<br>Filtration |
| 3. Turbid and hard | Clarification | Mechanical presedimentation<br>Coagulation and softening |
| | Softening | Mechanical sedimentation<br>Plain sedimentation<br>Filtration |

These three types of treatment are well known. It is conservatively estimated that they cover 80 percent of the problems encountered in water works practice. Simple as they are, they have been the subect of much study by the leaders in the development of modern practice, as Hoover, McDonnell, Graf, Fleming. They have been instrumental in moulding practice in each case to a point where chemical and mechanical controls approach closely to perfection. As this paper cannot attempt to deal with all phases of improved technique, it will attempt simply to show the relationship of mechanical clarifiers to each of these three common problems, quoting operating figures at typical installations insofar as possible.

## CASE I

### *Turbid, soft water*

Water containing excessive amounts of suspended solids, yet in other respects, such as hardness, suitable for domestic and industrial use, is found chiefly along the seaboard as distinguished from the great hard water section in the mid-western and central portion of the country. Figure 4 shows diagrammatically and in simplified form the unit operations which are generally found in treatment plants handling water of this character.

The turbid water is treated with suitable coagulants, such as alum or iron sulfate, and properly conditioned or coagulated in a series of agitation tanks in which mixing is maintained at a velocity suited to rapid flocculation. In the mechanical sedimentation tank the

floc settles rapidly, yielding a clarified effluent from which the slight remaining turbidity may be readily removed on rapid sand filters. Chlorination after filtration may or may not be employed, depending upon local conditions.

The plant of the city of Lancaster, Pa., is typical of this form of treatment. Table 1 gives the salient features of the chemical treatment and the operating results of the mechanical clarifier.

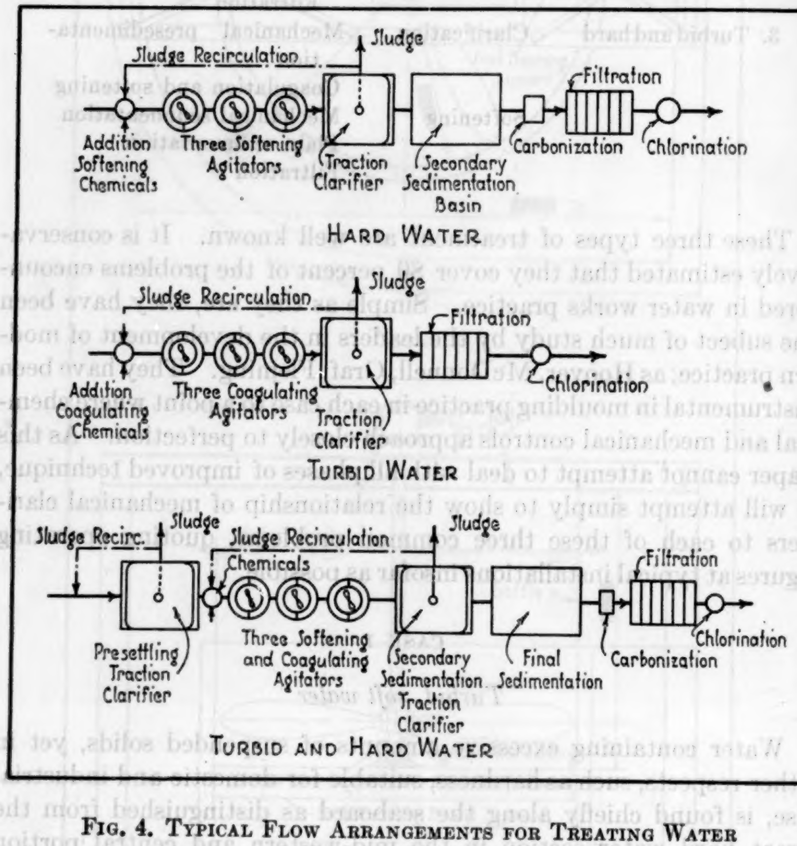


FIG. 4. TYPICAL FLOW ARRANGEMENTS FOR TREATING WATER

## CASE II

### *Clear, hard water*

Clear water, excessively hard, is a common occurrence in the great hard water section of the middle west and the southwest. This condition is particularly prevalent in Ohio, Illinois and Michigan where

many modern softening plants are found. The type of treatment used successfully for water of this character is shown in figure 4.

The hard water is dosed with the correct amount of softening chemicals, and the softening reaction and formation of flocs completed in the agitator tanks which follow. In the mechanical sedimentation basins the bulk of the floc is removed so that the duty on the plain sedimentation tank is greatly reduced, thus minimizing sludge accumulation and the need for frequent cleaning. The settled water is finally treated on rapid sand filters, preceded by carbonation and followed by chlorination if local conditions make these additional steps desirable.

In the recently designed water softening plants for the cities of Fostoria, O., Bloomington, Ill. and Boca Raton, Fla., plain sedimentation tanks have been eliminated. Single stage sedimentation in

TABLE 1

*Treatment of turbid water*

| | LANCASTER, PA. |
|---|---|
| Year installed | 1926 |
| Chemical coagulants used | Alum |
| Flow, m.g.d. | 9–12 |
| Size Dorr Traction Clarifier, feet | 80 |
| Detention provided, hour | 1 |
| Feed concentration, p.p.m. | Max. 2,000 |
| Feed concentration, p.p.m. | Aver. 80 |
| Overflow concentration, p.p.m. | 15–18 |
| Clarification efficiency, percent | 80–99 |

mechanical clarifiers yields an effluent containing such a small amount of suspended solids that final treatment on rapid sand filters is all that is required. Such plants as these are 100 percent mechanically operated as far as sludge handling is concerned.

Table 2 gives operating data at five representative waterworks handling hard water. The treatment in general follows the lines laid down in figure 4. The raw water is clear in most cases as it comes from deep wells. The Dorr Clarifiers, which in each case remove the bulk of the floc ahead of plain settling basins, effect a 75 to 98 percent removal of the precipitated solids, thus greatly reducing the duty on the subsequent equipment.

TABLE 2
*Treatment of hard water*

| | BEVERLY HILLS, CAL. | HINSDALE, ILL. | NEWARK, O. | GREENVILLE, O. | MIAMI, FLA. |
|---|---|---|---|---|---|
| Year installed | 1928 | 1925 | 1922 | 1925 | 1925 |
| Chemical softeners used | Lime—alum | Lime—soda ash | Lime, soda ash—alum | Lime—alum, soda ash | Lime—alum |
| Flow, m.g.d. | 5 | 3 | 6 | 1 | 10 |
| Size Dorr Clarifiers, feet | 1–60 | 1–28 | 1–40 | 1–22 | 1–60 |
| Detention provided, minutes | 60 | 60 | 22 | 42 | 60 |
| Clarifier feed: | | | | | |
| Alkalinity, p.p.m. | 7.8–8.0 | 375 | 42 | 365 | 247 |
| Soap hardness, p.p.m. | 220 | 472 | 275 | 445 | 295 |
| Clarifier overflow: | | | | | |
| Alkalinity, p.p.m. | | 110–140 | 40 | 82 | 38 |
| Soap hardness, p.p.m. | 130 | 90–120 | 87 | 125 | 86 |
| Clarifier sludge: | | | | | |
| Water, percent | | | 85 | 90 | 95 |
| Removal suspension solids, percent | 93.5 | 75 | 98.5 | 90–94 | |

*Treatment after mechanical clarification*

Beverly Hills, California:
1. Secondary alum coagulation
2. Secondary sedimentation
3. Filtration

Hinsdale, Illinois:
1. Secondary sedimentation
2. Carbonation
3. Filtration

Newark, Ohio:
1. Secondary sedimentation
2. Carbonation
3. Filtration
4. Chlorination

Greenville, Ohio:
1. Secondary sedimentation
2. Carbonation
3. Filtration

Miami, Florida:
1. Secondary sedimentation
2. Carbonation
3. Filtration

CASE III

*Turbid hard water*

That portion of the country which is drained by the Mississippi, Missouri, Arkansas and Red Rivers is noted for the high turbidity and moderate hardness of its water supply. These hard river waters contain turbidities ranging from 3000 to 10,000 p.p.m. Often for as long as a week the turbidity stays at 18,000 p.p.m. or higher, while for short periods turbidities of 40,000 p.p.m. have been observed. The difficulty of keeping non-mechanical sedimentation equipment in service under such conditions, may be visualized by considering the following. A turbidity of 10,000 p.p.m. is equivalent to 5830 cubic feet of 80 percent moisture sludge per million gallons of water treated. With such an average turbidity, a sedimentation basin having a detention of twenty-four hours will be full of mud in 23 days, with twelve hours detention in 11.5 days and with six hours detention in 5.7 days.

The manual cleaning of settling basins in this section used to be a frequent and major operation, often requiring several weeks work and the use of a large number of tractors, motor vehicles and teams in addition to a large force of men. Nowhere, it is safe to say, has the mechanically cleaned sedimentation basin helped so greatly in water works practice. The approved layout for handling turbid hard water provides for mechanical presedimentation ahead of chemical treatment and secondary mechanical sedimentation following chemical treatment as shown in figure 4.

The highly turbid raw water enters the mechanically cleaned presedimentation basins depositing therein about 90 percent of suspended solids which are continuously discharged into the river. The presettled water is thereupon mixed with suitable softening chemicals, agitated at a velocity conducive to rapid flocculation and then resettled in the mechanically cleaned secondary sedimentation basins. The overflow from these, containing only a small amount of suspended material, is given a long detention in simple sedimentation tanks and filtered with or without prior carbonation and subsequent chlorination as the situation may require.

With such an arrangement the difficulties attending the handling of highly turbid waters largely disappear. Practically all of the mud and precipitate is removed and disposed of mechanically, thereby reducing the deposition in the final non-mechanical basins and filters to

insignificant volume. Presettling furthermore, by reason of the low turbidity effluent, results in smoother plant operation, simpler chemical control, practically halves the cost of chemicals for coagulation and softening and reduces the cost of the water wasted with the sludge, as this water has not been given the expensive chemical treatment. Furthermore, the return of a portion of raw sludge to the influent channel of the presedimentation clarifier improves the rate of settlement, presumably through entrainment of fines. A similar recirculation of chemically treated sludge in the case of the secondary clarifier has been shown to accelerate the rate of softening, probably

TABLE 3

*Presedimentation tests at Jefferson City, Mo.—July 15–18, 1926*

| | |
|---|---|
| Source of water supply | Missouri River |
| Average suspended solids in raw water | 5,844 p.p.m. |
| Type and size presedimentation unit | Dorr Clarifier 25 feet diameter by 8 feet deep |
| Detention provided in presedimentation unit | 3 hours |
| Average suspended solids in overflow from presedimentation unit | 417 p.p.m. |
| Average removal of suspended solids | 92.8 percent |
| Type and quantity of chemicals added to presettled water: | |
| Iron sulfate (average dose) | 3.2 grains per gallon |
| Lime (average dose) | 3.6 grains per gallon |
| Secondary sedimentation unit | 15 feet by 15 feet plain basin |
| Average suspended solids in overflow from secondary sedimentation unit | 36 p.p.m. |
| Average removal of suspended solids | 91.5 percent |

due to a reduction in supersaturation or a catalytic speeding up of the reaction.

The use of the mechanical clarifier for presettling turbid water is a comparatively recent development. Four cities—Kansas City, St. Louis, Jefferson City, Mo. and Edmonton, Alberta—with a combined flow of 200 m.g.d. have adopted Dorr Clarifiers for presettling, while St. Louis uses the clarifier for settling the chemically softened presettled water as well. In none of these cases are operating data available at the present time.

Studies made at Jefferson City, Mo., in 1925 brought out on a semi-

works scale the most important data bearing on presedimentation practice. Operating results at Jefferson City during an eleven day run show the character of the results which should soon be obtained at the large installation referred to previously. These findings are shown in table 3.

Presedimentation of turbid waters before chemical treatments results in a great saving in chemicals as the chemical dosage increases with the concentration of solids. Runs made at Jefferson City, treating the raw river water without presettling, showed that the coagulants required for clarification could be reduced to approximately one-half their former amount, if the raw water were first presettled for three hours. Fleming, in a paper on Preliminary Sedimentation and Basin Detention at St. Louis, read in January, 1927, before the American Water Works Association, showed that his studies indicated an annual saving of $53,313 in iron sulfate and lime through subjecting 80 m.g.d. of Missouri River water to three hours of presettling before the addition of chemicals.

The three flowsheets discussed in this paper are not to be construed as panaceas for all problems, for each problem is different from all others in a greater or less degree and must be approached from the professional angle as a separate and distinct one. Nevertheless the flow sheets presented do indicate the general features of plants having to contend with three frequently encountered water conditions. They bring out the approved position of the mechanical clarifier with respect to other units in the layout.

The elimination of the difficulties inherent in the operation of intermittently cleaned settling tanks has undoubtedly been a forward step at many waterworks recently built or remodeled. The inevitable change in practice has had the cumulative effect of reducing the cost of producing a unit of potable water through continuous operation under uniform conditions which are conducive to simpler mechanical and chemical controls.

# WATER-BORNE DISEASE EPIDEMICS ON SHIPS[1]

By Isador W. Mendelsohn,[2] Louis Schwartz,[3] and George H. Ferguson[4]

Improvements in transportation, in promoting public travel for business, tourist, and social purposes, increase the problems of the public health authorities, making it necessary continually to institute more effective measures in discovering and stamping out promptly communicable disease outbreaks.

In 1902 (1), 1909 (2), and 1911 (3), Surgeons Young and Cobb of the United States Public Health Service found the high typhoid fever incidence among Great Lakes seamen to be due to the use of polluted lake water for drinking and culinary purposes. In 1912 (4), Surgeon Lumsden in his report on an outbreak on a Mississippi River excursion vessel, attributed the cause to polluted drinking water. Other water-borne disease outbreaks on ships have occurred since then in various sections of the country, as indicated in table 1.

Because of these epidemics, the Interstate Quarantine Regulations of the United States were amended in 1913 to include the control of drinking water supplies aboard interstate carriers. In 1915 (9) and 1916 (10), a study of drinking water conditions on Great Lakes vessels was made by the United States Public Health Service, as a result of which regulations were promulgated to insure safe ship drinking water supplies. With the entry of this country in the World War in 1917, the work was interrupted. It was not until 1921 (11) that this supervision was resumed. The country was divided into eight interstate sanitary districts (now reduced to five), each in charge of a sanitary engineer. The supervisory measures (12) included certification of water supplies ashore in coöperation with

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state departments of health, and certification of vessel drinking-culinary water supply systems (13), (14), (15), (including treatment apparatus where used) based upon inspections by the district personnel.

The magnitude of the work involved can be approximated from the fact that in 1928 there were 300 vessel shore water supplies and 2460 vessels. Control measures necessitated thorough inspection of the

TABLE 1

*Water-borne disease epidemics on ships in the United States*

| VESSEL | DATE | NUMBER OF CASES: Gastroenteritis | NUMBER OF CASES: Typhoid | DEATHS | CAUSE—WATER OF |
|---|---|---|---|---|---|
| Great Lakes steamer (3) | 1907 | | 77 | | Detroit River |
| *G. W. Hill* (4) | August, 1912 | 600 | 13 | 5 | Mississippi River |
| U. S. S. *Gopher* (5) | August, 1913 | 85 | 3 | | Great Lakes |
| *Huron* (5) | August, 1913 | 150 | 7 | 1 | Lake Erie |
| *Rochester* (7) | September, 1913 | 122 | 42 | 5 | Detroit River |
| *South American* (8) | June, 1915 | | 11 | | St. Mary's River, Great Lakes |
| Government dredge (6) | 1916 | | | | Mississippi River |
| *G. W. Hill* (6) | 1920 | 600* | | | Mississippi River |
| *Capitol* (6) | 1920 | 600* | | | Mississippi River |
| *Pioneer* | 1920 | 18 | 5 | | Delaware River |
| *C. W. Morse* (6) | August, 1920 | | 4 | | Hudson River |
| *Lake Gaither* | November, 1926 | 14 | 7 | 1 | Lake Erie |

* Note: The official reports of these investigations indicate the number of gastrointestinal cases to be at least 600 in each, besides an unknown number of cases of typhoid fever.

piping systems and general sanitary conditions of vessels; elimination of all cross-connections between the drinking-culinary water system and the overboard water systems; prevention of contamination of the drinking-culinary water by proper storage of the filling hose, satisfactorily designed filling pipes and manhole covers to storage tanks, removal of toilet and waste pipes from drinking water storage tanks, elimination of lead piping in the distribution system, and

separation of ice from water in coolers; continuous and efficient operation of stills, ultra-violet ray sterilizers, chlorometers, and filters on more than 500 boats taking their water from the Great Lakes and over 100 vessels taking their water from the Mississippi and Ohio Rivers; removal of overboard water supplies used in the preparation of foods from galleys and pantries; and prevention of use of impure water for drinking by mistake through removal of taps or posting of suitable warning signs. These control measures now extend to shipbuilding companies so that plans for drinking water systems are reviewed for approval prior to the launching of the ships.

Another phase of this sanitary control of vessels concerned their disposal of sewage, particularly on the Great Lakes (16). It was not until January, 1914, when the Progress Report of the International Joint Commission on the Pollution of Boundary Waters was published, that the seriousness of pollution of the Great Lakes by vessels was appreciated. Vessel sewage was considered next in importance to municipal sewage as a factor in the pollution of the boundary waters. Extensive series of analyses made in 1913 showed that the unrestricted discharge of sewage from vessels: (1) Menaced the water supply for summer residents and pleasure boats in St. Mary's River, lower end of Lake Huron, Lake St. Claire, and about the Thousand Islands; and (2) seriously polluted the waters in the lanes of vessel travel. In the Final Report of the International Joint Commission issued in 1918, one of the conclusions was that "vessel pollution in certain parts of boundary waters exists to an extent which causes substantial injury to health and property." The Commission recommended disinfection of vessel sewage before discharge. In accord with this recommendation, the United States Public Health Service made experiments showing the feasibility of steam disinfection (17) of vessel sewage before discharge. A practical test of an automatic apparatus designed for this purpose and carried out through two complete seasons upon the lake S. S. *D. C. Kerr* met with success both as to mechanical operation and bacteriological efficiency. The installation of this apparatus was quite inexpensive.

In 1921, arrangements were completed with companies at Cleveland to lock all public toilets on their vessels approaching and leaving the harbor until they were at least three miles from waterworks intake or bathing beaches, and to change the course of certain

vessels to take them farther from the bathing beaches. In 1926, largely through the efforts of the Division of Water Safety Control of the Chicago Department of Public Works, shipping officials arranged to lock all toilets aboard vessels while in the Chicago harbor and the vicinity of the intakes and beaches. Many of the passenger vessels installed sewage retention tanks and hypochlorite filters for sterilizing the sewage effluent. At other lake ports, such as Milwaukee, Detroit and Duluth, the pollution resulting from municipal sewage was considerably greater than that from the vessels, so that regulation of vessel sewage would not be of advantage until the city sewage was disposed of more satisfactorily. In the future the problem of pollution of the lakes by vessels will become more serious with the opening of the lake ports to foreign shipping.

TABLE 2

*Typhoid fever cases among seamen on American vessels on the Great Lakes hospitalized since 1915*

| NAVIGATION SEASON | CASES | NAVIGATION SEASON | CASES |
|---|---|---|---|
| 1915 | 60 | 1922 | 17 |
| 1916 | 70 | 1923 | 25 |
| 1917 | 49 | 1924 | 21 |
| 1918 | 39 | 1925 | 7 |
| 1919 | 24 | 1926 | 29* |
| 1920 | 20 | 1927 | 10 |
| 1921 | 13 | 1928 | 6† |

* Includes cases in outbreak aboard S. S. *Lake Gaither*.

† Up to July 1, 1928.

The effect of this vessel supervision has been decisive in that but one waterborne disease outbreak has occurred on a vessel since 1921, and the incidence of typhoid fever and dysentery in seamen has been reduced materially. In illustration of the latter fact, table 2 is presented:

This supervision has been fruitful in other ways. General sanitary conditions aboard passenger and freight vessels prior to 1915 were unsatisfactory. Subsequently, attention has been directed to crew's living quarters, food storage and preparation facilities, passenger quarters, etc., with the result that considerable improvement has been effected.

WATER-BORNE DISEASE OUTBREAK ON THE S. S. "LAKE GAITHER"

As previously mentioned, there has been but one outbreak of water-borne disease on an American vessel operating in interstate traffic since 1921. This case was on the S. S. *Lake Gaither* which was a United States Shipping Board vessel of 2689 gross tonnage and crew of 29. It was bought by the Western Reserve Navigation Company of Cleveland, Ohio, and operated early in 1926 in coastwise and foreign service from Atlantic Coast seaports such as New York, Philadelphia, Baltimore, Newport News, Norfolk, Miami, Tampa and St. Petersburg. Water for drinking-culinary purposes aboard the vessel while in this service was obtained from approved shore supplies.

While loading her first cargo for the Great Lakes, the manager of the company wrote a letter dated May 24, 1926, to the captain and chief engineer, instructing them, in accordance with the Interstate Quarantine Regulations of the United States with which the company was familiar as applying for several years in the past to their passenger vessel on the Great Lakes, to fill drinking water tanks from shore supplies wherever possible; and, if it was necessary to take lake water for this purpose, to have the water treated in the still aboard. The still was supplied by a pump with a sea suction. The *Lake Gaither* made several trips to the Great Lakes in 1926 before the one referred to in this account.

On October 9, 1926, the *Lake Gaither* arrived at Montreal from Rotterdam, having proceeded from Buffalo to Rotterdam about three months before. Seven of the crew were discharged and seven were signed on in their place. The vessel then left for Detroit through Canadian waters. Water was taken from overboard in Lakes Ontario and Erie (the latter on October 14, 1926) through a seacock and suction pipe to a pump and forced through a canvas hose hook-up with a water plug connection flush with the boat deck to the two fresh water tanks holding approximately 12 tons each (equivalent to 3,000 gallons each). This water was used untreated for all domestic purposes aboard.

The vessel docked at Detroit on October 14. While at Detroit from this date till November 1, the fresh water tanks were filled with water from the city supply by hose connection with hydrants on the docks. Nine of the crew, including the cook, were discharged at Detroit, and, by October 25, nine new men including two cooks

were signed on. A new captain and a new chief engineer were also taken on. The vessel loaded automobiles for Santos, Brazil.

On November 1, 1926, the ship left Detroit for Toronto, proceeding again in Canadian waters. Water from Lake Erie was pumped into the fresh water tanks on the same day, a few hours out of Detroit harbor. At this point Lake Erie is heavily polluted with sewage from cities bordering the lake and from vessels.

There were no cases of illness aboard the vessel until she left Detroit. Diarrhea broke out among the crew, the first case about November 1. On November 6, one of the men, an oiler, hired at Montreal on October 9, was laid up in bed. He was hospitalized for typhoid fever at Toronto on November 8, upon the ship's arrival. On the 7th, another member of the crew, a fireman hired at Detroit on October 21, was laid up and was hospitalized for typhoid fever at Toronto on November 9. On the 9th, a messroom boy, hired at Detroit on October 21, became ill and was hospitalized for typhoid fever on the 10th at Toronto. At Toronto, automobiles were loaded on the vessel and water for drinking-culinary purposes was taken from the city supply in pails.

On the 16th, a sample of the drinking water was collected by the Health Department Laboratory at Toronto. Upon analysis it was found to contain B. coli in 10 cc. portions, with a count of 1040 colonies. Immediately upon receipt of information from the Chief Medical Officer of Health of Toronto of the hospitalization of three members of the crew with typhoid fever, Chief Engineer Ferguson of the Canadian Health Department telegraphed the facts to Associate Sanitary Engineer Mendelsohn in charge of Interstate Sanitary District No. 3 at Chicago. Because of other pressing duties at the time, the latter replied by telegraph requesting the coöperation of the Canadian Health Department in making an investigation of the outbreak. Dr. Amyot, Deputy Minister of the Canadian Department of Health, detailed Chief Engineer Ferguson to make the investigation and requested the coöperation of Surgeon Schwartz stationed at Montreal.

The *Lake Gaither* left Toronto on November 17 and arrived at Montreal on the 26th, proceeding in Canadian waters. On the 20th, another member of the crew who was hired at Buffalo on July 10, 1926, became ill and was hospitalized for typhoid fever at Montreal on the 25th. He died on December 3. On the 23rd, a seaman

hired on October 30 at Detroit became ill and was hospitalized for typhoid fever on the 25th.

Immediately upon arrival at Montreal, the vessel was boarded by Surgeon Schwartz and Engineer Ferguson. Dr. Schwartz investigated the outbreak of the disease, obtaining information from the captain, supercargo, and chief steward, and directed the hospitalization of the two men at Montreal. Engineer Ferguson investigated the water supply system, obtaining data from the assistant engineer, the captain and purser. Water samples were collected and analyzed at the Canadian Department of Health Laboratory on the 26th. On November 28th, another seaman was hospitalized for typhoid fever at Montreal, and on the 29th, still another.

TABLE 3

*Occurrence of typhoid fever cases on S. S. Lake Gaither in 1926*

| CASE NUMBER | AGE | EMPLOYMENT ON VESSEL | SIGNED ON VESSEL | | DATE OF ONSET | NUMBER OF DAYS AFTER LEAVING DETROIT |
|---|---|---|---|---|---|---|
| | | | Date | Place | | |
| 1 | 23 | Oiler | October 9 | Montreal | November 6 | 5 |
| 2 | 38 | Fireman | October 21 | Detroit | November 7 | 6 |
| 3 | 22 | Messboy | October 21 | Detroit | November 9 | 8 |
| 4* | 26 | | July 10 | Buffalo | November 20 | 19 |
| 5 | | Seaman | October 30 | Detroit | November 23 | 22 |
| 6 | | Seaman | | | November 28 | 27 |
| 7 | | Seaman | | | November 29 | 28 |

* Died on December 3, 1926.

## HISTORY OF SICKNESS AMONG THE CREW

Between November 1 and 10, 14 of the crew had diarrhea, besides those who went to bed. The others, including one of the cooks, had no diarrhea. None of the crew gave a history of having had typhoid fever or any serious illness except the two cooks. One admitted having typhoid fever about 25 years before. He had diarrhea at the same time the other members of the crew had it. He was a cook on the S. S. *Canadiana* for four years previous to signing on the *Lake Gaither,* and in this period there was no illness on the *Canadiana.* The other cook signed at Detroit on October 25. He gave the history of being in a hospital at Detroit in 1920 from May 18 to June 10 with what was diagnosed as pneumonia, and of being sick for two weeks after his discharge from the hospital. Previous to signing on

the ship, he was a cook in a restaurant and did not know of any case of illness developing among those eating there.

### HISTORY OF FOOD SUPPLY

No shellfish other than canned clams were served to the crew. Only canned milk was used aboard. Fresh vegetables were obtained in Detroit while the ship was at dock.

### HISTORY OF THE DRINKING WATER SUPPLY

The two fresh water tanks previously mentioned had been scrubbed and cleaned in Buffalo before sailing for Rotterdam. In filling these tanks with city water from approved shore supplies, a hose was connected with the deck plug. These tanks were connected with a 200 gallon tank receiving distilled water from the still when the latter was in operation. In this manner, water from the two fresh water tanks could be turned into the distilled water tank without passing through the still. The still was not operated on the Great Lakes trip in question, nor on the preceding trip.

The mate filled the two fresh water tanks with raw lake water acting under the direction of the master of the ship. The captain believed that the still on the vessel was continually in operation, and that these tanks were the source, as in the case of a good many lake steamers, from which water was pumped to the still, after which the distilled water flowed by gravity to the drinking water tank (scuttle-butt) and faucets. He did not make the necessary effort to learn just how the drinking water system was installed on the steamer. Neither the chief engineer of the vessel nor any of his crew knew of water being pumped from the lakes into the two tanks, it being their understanding that the deck department obtained the water from approved shore supplies only.

Samples of water were collected from (1) the crew's drinking water tap on the main deck; (2) tap in engine room on drinking water system; and (3) tap in engine room on engine cooling system (water directly from overboard). The analyses of these were carried through the completed tests for the Coli-Aerogenes group and gave the following results: (1) 13,600 colonies per cubic centimeter and B. aerogenes; (2) 12,640 colonies per cubic centimeter and B. coli communior; and (3) B. coli communis.

## ACTION TAKEN TO PREVENT SPREAD OF DISEASE

Dr. Schwartz and Engineer Ferguson advised the captain to empty the drinking water tanks, scrub them and the other containers with bleaching powder, flush them out with city water, and refill them with city water. They recommended further that (1) the well members of the crew be sent to the Montreal General Hospital to receive immunizing doses of typhoid vaccine; (2) the two cooks report at this hospital for examination as possible typhoid fever carriers; and (3) the crew's quarters where the sick had been be thoroughly cleaned and scrubbed with bleaching powder. The tanks were immediately emptied and cleaned, and 21 members of the crew received doses of typhoid vaccine, a few receiving second and third doses. The two cooks failed to report for examination and it was found impossible to compel them to do so.

## ANALYSIS OF EPIDEMIOLOGICAL DATA

The history of the food supply seems negative, although the fresh vegetables bought in Detroit might be regarded with some suspicion. The history of the cooks as to being carriers also seems suggestive, as the typhoid fever cases developed after their signing on, the first case eleven days after. The absence of complete information on the one cook who had typhoid fever 25 years previous and the other cook who gave no history of typhoid or of any illness other than pneumonia 5 years before, other than that no cases developed subsequent to November 30, although the cooks remained aboard, makes it difficult to hold them responsible as carriers of typhoid.

The history of the water supply is suggestive, raw water from Lake Erie having been pumped into the tanks on October 14 and November 1 at points receiving considerable sewage. It seems to have been the practice of the officers to obtain drinking-cooking water frequently, either by pumping from overboard or from ashore, as the storage tank capacity was sufficient for 15 to 20 days supply normally. There can be little doubt that some of the lake water pumped October 14 was in the drinking-cooking water tanks while the vessel was at Detroit, and possibly for some time after. The quantity of lake water pumped most likely was diluted considerably with the water obtained from the Montreal public supply. This may account for the fact that the first cases of diarrhea of record began November 1, 18 days after Lake Erie water was pumped, and the first case of typhoid (signed on in Montreal, October 9) went to bed on November

6, 23 days after such pumping. The second case developed November 7 in a man signed on at Detroit on October 21, 7 days after Lake Erie water first was pumped. The third case developed November 9 in another seaman signed on at Detroit on October 21. The fourth case did not develop until November 20, 19 days after the second pumping of Lake Erie water. The lapse of time between the occurrence of the third and fourth cases may be due to dilution of the original lake water pumped and subsequent reinfection with polluted lake water pumped after leaving Detroit. The occurrence of the latter cases indicates infection from the lake water pumped November 1. Diarrhea was present among the crew during the occurrence of the typhoid cases. It was found that those who first had the diarrhea and recovered did not have recurrent attacks, each additional case occurring in a new patient.

It is a well known fact (18) that in a water-borne outbreak of typhoid fever there is also a large number of cases of diarrhea and gastro-intestinal disturbances in which the precise etiological factor has not been discovered. Some of these cases may be mild instances of typhoid fever occurring in relatively immune people. So, in this instance, it is not unlikely that among the 14 cases of diarrhea which occurred on the ship there were mild cases of typhoid fever. There was no follow-up record of the 9 seamen who were discharged at Detroit, but it is known that two engineers of the company who worked on the vessel at Detroit developed similar illnesses lasting for about a month, shortly after returning to their homes in Cleveland.

There were no cases after the tanks were emptied, cleaned, and refilled with good water. The analyses of the water confirm the impurity of the lake water pumped. In view of these data, the outbreak is attributed to the use of impure lake water for drinking purposes.

## LATER DEVELOPMENTS

In January, 1927, an effort was made to institute civil and possibly criminal action against the responsible officers of the vessel and the company. The Local Inspectors of the United States Steamboat Inspection Service at Cleveland, Ohio, held an extended hearing in which considerable information was obtained. However, the evidence was not sufficiently complete to warrant successful court proceedings by the United States Attorney. No civil suits (8) were instituted against the company by any of the sufferers. On May

9, 1927, the vessel was auctioned off to settle sundry attachments, and is at present engaged in commerce on the Atlantic Ocean.

The outbreak is noteworthy on three counts, namely, (1) the study indicated the use of polluted lake water for drinking and culinary purposes as the cause; (2) there was a lack of coöperation between the captain and chief engineer as to the supply of drinking-culinary water, and inadequate knowledge of the water system by the captain; and (3) the spread of the disease was controlled quickly and effectively through coöperation with the Canadian Federal Health Authorities.

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## *DISCUSSION*

JOEL I. CONNOLLY:[5] This paper has given a very interesting account emphasizing again the great necessity for care in handling water supplies where more than one water supply is available. In their homes and offices the great majority of people have but one water supply, and the possibility of its contamination does not occur to them. On a lake vessel the existence of an inexhaustible supply of water overboard, and of seacocks and pumps for making it easily available, constitutes a threat to the safety of the water supply used for drinking purposes, especially where, as in the case of the steamship "Lake Gaither," a cross-connection exists between the raw water and the distilled water tanks by means of which raw water could be bypassed around the still and enter the scuttle-butt and drinking water faucets.

A cross-connection of this character should not be permitted at any time, but its danger becomes accentuated when coupled with lack of coöperation between the deck and the engineering departments of the vessel. The responsibility of vessel captains for knowing the conditions of their water supply systems must be constantly stressed if repetitions of such epidemics are to be avoided. In addition, education of the crew to use the treated water must be carried on constantly.

A conversation with the chief engineer of a tow-boat on the Ohio River several years ago is recalled. I met the chief engineer of this boat aboard the vessel and inquired as to the condition of his water

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still for treating the river water to make it suitable for drinking purposes. He replied "It's working fine—you know I drink that water myself now." I replied "I am glad that you are—haven't you been up to now?" "Oh, no, I never used to drink that distilled water; all we used it for was to wash our clothes because it is soft. But the other day I was sitting on the bank just below that sewer," (indicating a nearby sewer outfall, with his finger) "and I got to thinking that I was drinking a lot of that stuff that came out of the sewer, so I decided to drink the distilled water."

The water still has been aboard that boat for several years, but he and other members of the crew had continued to drink the raw river water and it was only the revulsion against the idea of drinking sewage that caused him to change, instead of a proper realization of the danger to his health.

Cross-connections on those river boats were the rule rather than the exception ten years ago and many of these vessels had four distinct characters of water supply. For instance, there was the raw water used for washing decks and fire protection; there was river water filtered, usually by a stone filter, used for washing purposes in the staterooms, which was unsafe to drink because of the low bacteriological efficiency of the filters in removing disease germs; there was the hot water supply from the boilers used in the kitchen for washing dishes, and the distilled water for drinking and culinary purposes.

Unknown to many water-works officials there exists a similar condition in many of the most modern hospitals. There are three water supplies almost invariably cross-connected in such a way as to permit their mixing together. There is the public water supply of a character safe for drinking purposes, but not sterile and therefore unsuitable for surgical use; there is the sterilized water provided for use in the operating room, and the distilled water supply for laboratory and sometimes surgical use. The condition of frequent cross-connections found a decade ago on many steamboats exists today in hospitals in the cross-connections of these three water supplies, to which attention was directed by Dr. Arnold H. Kegel, commissioner of health of Chicago a year ago. In addition to being cross-connected to each other these water supplies are frequently so connected to the waste lines as to permit their pollution by sewage. Submerged inlets to sterilizers, direct connections from cooling coils in water stills and sterilizers to the waste pipes, and by-passes around the

sterilizing apparatus similar to the by-pass around the water still on the "Lake Gaither" all menace the safety of the drinking water supply and of the patients upon whom operations are performed.

Many cases have been found where sewage could find its way directly into the sterile water taps in the operating room, or into the baby's nursery in the obstetrical wards of hospitals. Less than two weeks ago the writer, in testing a vacuum breaker intended to be used with flushometer valves to prevent siphoning of fixture contents back into the water supply pipes, found that it was possible, in spite of this protective device, to siphon carbol-fuchsin dye out of a bed-pan washer in a hospital and recover the dye at the faucets in the sink in the utility room on a lower floor.

This cross-connection through the flushometer valve was a dangerous one, as the contents of a bed-pan used by a sick patient in the hospital could be siphoned, just as in the case of the dye, through the valve into the water supply of the hospital. The vacuum breaker which the manufacturers of the flush valve had designed to prevent siphonage failed because the air opening was too small to be effective. Air could not enter the pipe rapidly enough to break the vacuum and prevent siphonage.

This matter is mentioned incidentally because it is one of great importance to water-works and health officials, and because it was the experience of the writer in ferreting out cross-connections aboard great lakes steamships and river vessels on the inland rivers that made possible the discovery of many of these similar cross-connections in hospitals.

The education of the seaman is of great importance because it is just as true of the man as of the horse that "you can lead him to water but you can't make him drink." An analysis of the occupation of seamen hospitalized for typhoid fever in the Great Lakes district made several years ago indicated that by far the greater proportion were those having easy access to an untreated water supply, such as firemen who drank from the hose provided for wetting down ashes and clinkers drawn from the fire, and engineers and oilers who drank from the jets of untreated water playing upon the bearings of the engines to keep them cool. These men could drink the distilled water, but because, in some instances, it required the effort to climb up out of the stoke-hole to get it, and also because of the flat taste of distilled water, they preferred to drink the raw lake water and incur the risk of sickness.

It is realized, of course, that the education of such men is not the function of the water-works official, but I would like to urge all water-works men in cities where vessels may stop to take water from ashore to coöperate with the vessel companies in providing means for getting the water aboard the vessel with the greatest ease and safety.

In Chicago, the city has provided convenient outlets where vessels dock so that a short length of hose may be connected from one of these outlets to a coupling at the side of the vessel on a pipe leading to the drinking water storage tank.

Pittsburg, Memphis and many other river cities coöperated in this matter a number of years ago by installing, at the expense of the city, pipe lines on the river bank with outlets at different levels, so that filling the drinking water tanks aboard river steamers by using short lengths of hose was possible, regardless of the stage of the river. Such measures, coupled with the continued support of health agencies in educating the public against the hazards of drinking water, the source of which is not definitely known, are certain to be productive of beneficial results. We can all take our cue from the excellent coöperation shown by this paper to exist between the Dominion of Canada and the United States in preventing the further spread of typhoid fever upon the steamship *Lake Gaither*.

# THE DURABILITY OF DISTRIBUTION SYSTEMS[1]

By Harry Y. Carson[2]

The writer has spent much time especially in studying causes for the disintegration of gas and water distribution systems, as well as other buried structures. The remarkably long life of cast iron pipe and the extremely short usefulness of some other pipe materials are themes of particular interest to water works men, especially if, in our discussion, we can offer practical suggestions.

The various public utilities, the agencies regulating plumbing and those who have jurisdiction over sewerage, public streets, etc., should have closer coöperation. City governments should require better planning of underground piping and in such planning one of the prime factors to be considered is the relative durability of materials.

The paper on the "Two Main System of Water Distribution" presented at this convention by J. B. Eddy of Chicago clearly shows the need for proper allocation of various distribution lines. House service connections of relatively short life should be abolished from under city pavements.

### RUSTED SERVICE PIPES

Some data are presented in a paper[3] read before the New York Section of The Association on February 21, 1917, which will bear repeating:

*Plumbing and wasted water*. . . . The habit has been too common of thinking that the responsibility ends at the corporation cock on the street main or at the meter. That responsibility should not end short of the spigot on each plumbing fixture.

The New England Water Works Association received last year (1916) an excellent report on service pipes in which the following table was given to show the comparative life of some materials which have been used:

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[1] Presented before the Toronto Convention, June 26, 1929.

[2] Research Engineer, National Cast Iron Pipe Company, Birmingham, Ala.

[3] Rusting of Pipe in Service, Harry Y. Carson, Journal, June, 1917, page 258.

| | YEARS BEFORE TROUBLE BEGINS | LIFE OF PIPE, YEARS |
|---|---|---|
| Plain (black) iron or steel pipe | 12 | 16 |
| Galvanized Pipe | 15 | 20 |
| Lead Pipe | 10 | 35 |
| Lead Lined Pipe | 10 | 23 |
| Cement Lined Pipe | 14 | 28 |

These data are valuable as giving some idea of the amount of water wasted from steel and wrought iron service pipes, which wastes through rust holes in the pipe long before the trouble is detected. Moreover, it becomes difficult to learn the amount of wastage until the line is torn up and replaced. The table also shows that galvanized pipe is little better than black pipe.

The above interesting data throw light on the development of cement linings. Subsequent studies[4] have shown that in a few places where the service pipes escaped average soil corrosion, cement linings, (as thin as $\frac{1}{32}$-inch) withstood the rusting action of soft New England water longer than 50 years. Consequently, it is clear that the average life of cement lined wrought iron service pipes, which, in the above table is given at 28 years, represents the total effect of external soil corrosion on this particular material and is exclusive of any internal corrosion. If we now compare this with the average life of black wrought iron or steel pipe amounting to 16 years, it is evident that the effect of the internal corrosion on uncoated wrought iron or steel is almost equal to the effect of external soil corrosion. Cement linings not only do increase the durability of pipe, but also greatly improve the flow values.

### EFFECT OF SOIL CORROSION ON UNCOATED CAST IRON MAINS

Water works men may have no direct interest in the durability of gas mains. However, when the same kind of pipe is used for water and gas mains, experience in the one field may be of considerable benefit to the other. It is for this reason we bring before this body of water works men some data on cast iron pipe used in gas distribution systems.

An excellent opportunity was afforded the writer to study the effect of external corrosion on uncoated cast iron pipes at Washington, D. C., during 1928, the work having been carefully done in coöpera-

[4] Cement Lined Water Mains, Harry Y. Carson, Industrial and Engineering Chemistry, 19: 7, July, 1927, p. 781.

tion with officials of the Washington Gas Light Company. The soil and the general corrosion factors at Washington, D. C., are not unlike conditions in New England except that the climate is warmer and, as we go southward, the corrosiveness increases slightly.

The depth of pipe lines varied from a few inches below the surface to about five feet of cover over the top of the pipe, and the amount of cover over the pipe seemed to have little or no effect upon the corrosion pressure exerted upon the pipe.

The texture of the soil determined very largely the amount of water and dissolved salts, and this has most to do with the degree of corrosion pressure exerted upon the external surfaces of the buried pipe lines.

By "corrosion pressure" we mean the intensity of hydrogen ions to pass through the protecting oxide, which naturally accumulates over the outside surfaces of the cast iron. During periods of time or seasons when the soil contains much moisture this "corrosion pressure" increases and tubercles which had become dormant when dry are caused to become active. Vice versa, when the soil and pipe become dry the active tubercles fail to transmit the active hydrogen ions and a dormant state is set up. Further, as the crust of oxide becomes thicker and thicker the hydrogen ions pass or diffuse more and more slowly to the iron and even where the "corrosion pressure" may be fairly high the rate of diffusion through the thick dense oxide coating slows up to a negligible quantity after the first eighty or one hundred years of service.

## EXAMPLES OF DURABILITY OF CAST IRON

The earliest authentic records concerning cast iron pipe relate to several old pipe lines of various diameters laid during 1664 to 1688 by order of Louis XIV, near Paris from the reservoirs of Picardy to those of Montbauron, together with the Spring Water Conduit, the whole supplying the Town and park of Versailles.[5] These pipes are still serving after 264 years, and as shown by figure 1, are in excellent condition. According to the report:[6]

> The few repairs which have been required have generally been necessitated by the bad condition of the flange bolts, which have rusted out.

[5] External Corrosion of Cast Iron Pipe, Marshall R. Pugh, Trans. A. Soc. C. E. Vol. XXVIII, page 806.

[6] The Life of Cast Iron Pipe, C. Cavallier, Jour. New England Water Works Assoc. June, 1904, page 218.

All the early pipe was cast with bolted flanged joints and that laid at Clermont-Ferraud in 1746, Saint Etienne in 1782 and other French cities has served, according to all reports, without any loss of service due either to soil corrosion or water corrosion.

London and Glasgow have a record of between one and two centuries for cast iron pipe. In 1785, Mr. Thomas Simpson, engineer of the Chelsea Water Company of London, designed and laid the first bell and spigot pipes.


FIG. 1. CAST IRON PIPE IN GOOD CONDITION AFTER 264 YEARS OF SERVICE AT THE FAMOUS VERSAILLES FOUNTAINS, NEAR PARIS, FRANCE

It has been this latter type of pipe which was first shipped into this country and subsequently made by American foundries in nine-foot lengths. We find that the pipe laid by the Washington Gas Light Company in 1848 was of this same early design. A curious feature about these early pipes is that each length had three or more raised sections or ribs approximately two inches in width, which were presumably to afford places with heavier walls in which to place the service tap. One of the early methods of inserting a service connec-

tion or tap to the main consisted of using a tapered fitting or ferrule which was driven into the drilled hole like a plug instead of the threaded fitting which is now so familiar.

It is a matter of interest here that pipe laid in Philadelphia in 1816 was found to be almost as good as new after 100 years of service, and observers have repeatedly summed up their conclusions by saying: "The experience of more than two hundred and fifty years with cast iron pipe has not been sufficiently long to establish just what its life is."

FIG. 2. 3-INCH CAST IRON MAIN LAID IN 1848

### SOME PHYSICAL AND CHEMICAL ASPECTS OF SOIL CORROSION

There are two general types of corrosion of cast iron pipe, one wherein the rust or oxide adheres tightly and is locked to the surface of the pipe with considerable force and the other wherein the product of corrosion is dissolved and removed or carried off in the water solution adjacent to the pipe surface.

In all observations of the mains of the Washington Gas Light Company the first general type of corrosion was noted, and no instance

of the second type of corrosion was found. A typical condition is shown in figure 2 which is an illustration of 3-inch cast iron main laid in 1848.

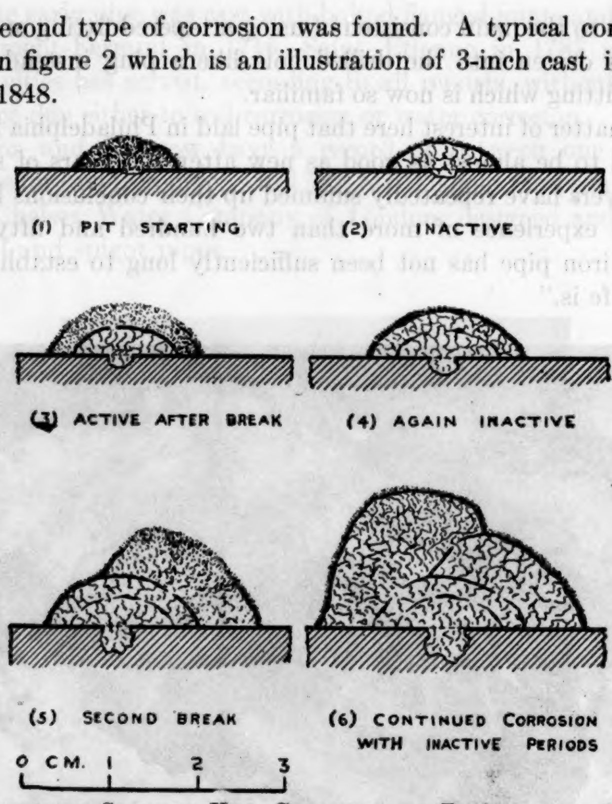


FIG. 3. SKETCHES SHOWING HOW CORROSION BY PITTING WITH OVERLYING TUBERCLES PROGRESSES

FIG. 4. THIS ILLUSTRATION IS OF A TYPICAL DORMANT OXIDE COVERING FOUND ON CAST IRON PIPE AT WASHINGTON, D. C. THE PORTION $\frac{1}{8}''$ THICK ADJACENT TO THE PIPE HAS A METALLIC CHARACTER, WHILE THAT FARTHER REMOVED IS MORE SPONGY AND OF LOWER STRENGTH, BUT THE WHOLE BODY OF THIS CRUST RESEMBLES A HARD CONCRETE STRUCTURE, THE CEMENTING SUBSTANCE BEING FERRIC AND FERROUS OXIDE.

There can be no question about the soil containing many diverse elements which exert a corrosion pressure on the external surfaces of buried pipe lines. Tree roots and bacterial growths generate acids which are carried by the rain water into the ground surrounding the pipes. Then there are salts which supply the necessary vehicle for chemical and electro-chemical reactions when dissolved in this water.

The degree of corrosion intensity depends largely upon the physical character of the soil, and as yet, we know little regarding this subject. Our studies thus far, however, indicate at least five or six groups of soil which probably will become identified after further research.

Our present interest is not so much concerned with the detailed mechanism of corrosion, which involves several hypotheses, but rather with the actual effect of the soil on the buried pipe lines.

Mr. John R. Baylis has set forth a description[7] of what takes place when an iron surface is exposed to corrosion, and we can subscribe to Mr. Baylis' explanation of the progressive stages of pitting and the formation of overlying tubercles. This is graphically shown in figure 3.

In time the tubercles or cementatious incrustations formed on the external surfaces of cast iron pipe by the soil, such as found in the District of Columbia become practically dormant and they enmesh portions of the clay, sand, or loam which is adjacent to the pipe surfaces. A typical section of this external cement-like crust is shown in figure 4.

### MECHANISM OF RUST ON CAST IRON AND WROUGHT IRON

Since many actual facts cannot be explained by chemical or electro-chemical hypotheses thus far advanced, we believe a clear explanation was set forth several years ago in the "Mechanical Theory of Corrosion."[8] The microphotograph of cast iron pipe shown in figure 5 is typical of the structure which is presented to the attack of oxygen and moisture while the microphotograph of wrought iron pipe shown in figure 6 is typical of the longitudinal pipe structure which is presented to soil corrosion by wrought iron and rolled steel pipe.

[7] Industrial and Engineering Chemistry, 18: 4, April, 1926, page 370.

[8] The Structural or Mechanical Theory of the Effect of Rust on Cast Iron, Wrought Iron and Steel, R. C. McWane and H. Y. Carson, Proc. American Foundrymen's Association, 24, page 593.

In the place of the interlocked grains or crystals of cast iron, wrought iron and rolled steel are found to have their crystals of iron oriented in a fibrous and in thinly rolled steel, in a laminated structure with distinct overlapping of the laminations. As corrosion takes place on wrought iron or rolled steel, these laminations or fibres scale off one from the other, or become so loosely bound together that constantly fresh surfaces are presented to the pressure of corrosion. The manipulation or rolling of steel or iron during the process of its manufacture thus unfits it to form its own protective coating, as does cast iron pipe when buried in soil.

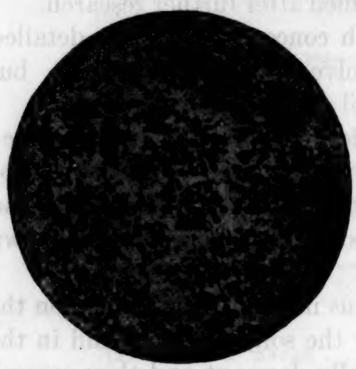

FIG. 5A. GRANULAR STRUCTURE OF CAST IRON

FIG. 5B. FLAKE-LIKE STRUCTURE OF WROUGHT IRON

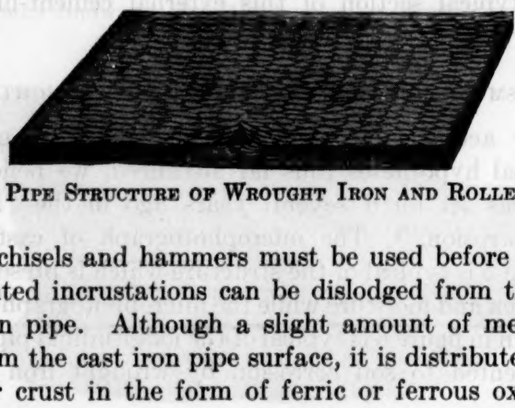

FIG. 6. PIPE STRUCTURE OF WROUGHT IRON AND ROLLED STEEL

Picks or chisels and hammers must be used before any of these outer cemented incrustations can be dislodged from the surface of the cast iron pipe. Although a slight amount of metal has been removed from the cast iron pipe surface, it is distributed or diffused in the outer crust in the form of ferric or ferrous oxide. As the metallic iron becomes completely oxidized its volume increases six to ten times (due to the addition of the element oxygen). If we consider that the iron is penetrated to an average depth of $\frac{1}{16}$-inch in a 6-inch pipe and this iron is changed to ferrous and ferric oxide the pipe instead of being 7 inches across its outside diameter will be

$7 + 2\ (\frac{1}{16} \times 8)$ or 8 inches outside diameter. This outer crust, which in many ways resembles a cement concrete, would accordingly have an average thickness of about ½-inch. Furthermore, it is of interest to calculate that the outer crust would only have to develop a unit strength of about one-tenth the strength of cast iron itself to be equivalent in every respect to new cast iron pipe.

A test made by the writer on December 4, 1928 from a specimen of oxide from a 3-inch cast iron pipe laid in 1872 at the northwest corner of Third and East Capitol streets, Washington, D. C., revealed a unit compressive strength of 8,880 pounds per square inch. These calculations and the test indicate the great strength of the iron oxide that overlies and tenaciously penetrates the external surfaces of the cast iron mains in the District of Columbia. They are further indications that cast iron mains have sufficient durability to withstand service conditions in water or gas distribution systems for an indefinite period of time.

## *DISCUSSION*

George H. Fenkell:[9] The subject under discussion is one of great interest worthy of our best thought. The pipe used in the distribution systems of our water works plants in the early days of water main construction, and in some places until quite recently was uncoated. Later cast iron pipe has been coated with an application of tar. There has been a feeling that this coating could be applied to the pipes in various ways. Various ways have been tried by the manufacturers and by water companies to get a more efficient coating, but these efforts have not always met with success.

It has not always been easy either to treat the water. There are very few cities that are equipped with treating plants, and for that reason the water has not been treated. We have had to trust to the coating on the pipe, and other methods that have been adopted.

In recent years steel and wrought iron have been used as water pipes, but unfortunately in the beginning of the manufacture of these pipes the manufacturers did not undertake, as far as I know, any exhaustive study to determine what was the best coating that could be used. The engineer specified the kind of coating he thought would best answer the purpose, and the manufacturers used that coating without investigating its usefulness.

[9] Superintendent and General Manager, Board of Water Commissioners, Detroit, Mich.

It has occurred to me that, through the great knowledge on this subject we have obtained through chemistry, perhaps the most hopeful method would be to treat the water. This can be done in a great many places, much more easily than formerly, because many are now equipped with treatment works, employ bacteriologists and chemists who are on duty at all times, and who are in a position to make a special study of the proper treatment of water for human consumption, and for preservation of pipes and other apparatus in water works operation.

The reason these advanced methods have not been used in the past is because the effect on the pipes of gas and other constituents has not been fully understood.

In places where the pipes suffer little from corrosion the question of scale and the incrustation that forms on the interior of boilers is becoming a very live issue. It has resulted in the consumer suffering. Here, too, as a result of careful chemical research, methods for removing the troubles caused by water in steam boilers are gradually being placed in use.

It seems to me that the time has arrived when water works men, through the aid of chemists and bacteriologists, should be able to approach this question in an intelligent way. What we need today is still more scientific study of this important question of corrosion. We must ascertain why the corrosive action is carried on, and when that is understood in a better degree than at present something can be done to prevent corrosion in the pipes.

It is not a simple problem, but it is not unlikely that a way will be developed whereby many plants will be able to protect their system against corrosion in the pipes to a much better extent than is possible today.

Andrew F. Macallum:[10] When I was engineer in the City of Hamilton it was found necessary to take up a water main that had been down for 60 years. When it was removed we found that there was no tuberculation whatever inside or outside. Hard water was supplied through these pipes, but it must be remembered that the quality of the iron used in the pipes at that time was much better than in present day pipe. This was old English pipe, and it was much better than we get today.

[10] Commissioner of Works and City Engineer, Ottawa, Ont., Can.

On the other hand, we found we were continually having trouble in the tubes in the boilers. We tried about all the known treatments, and we finally came to the conclusion that the tuberculation was caused by electrolysis.

In Ottawa we have a soft brown water, and we have tuberculation. I think the author suggested it would be better to clean the pipe. With our steel pipe, we remove the water and recoat the pipe. Do you think that is good practice?

Harry Y. Carson:[2] I think it would be well to bring out one of the studies we have made in connection with bituminous coating, and cement coating. Bituminous coating does not, from a theoretical standpoint, afford any protection against ionic diffusion. By that I mean the diffusion of hydrogen ion in one direction and oxygen ion in the opposite direction. Cement coating, for a peculiar reason, does not stop up, but it seals the diffusion action, and for that reason the cement affords protection against interchange of hydrogen ion and iron ion which extends the electric charge at the point of service.

Mr. Hazen brought out the point that perhaps the double dipping would fill up the microscopic pores in the coating. The tubercles do form on top of bituminous coating, and apparently in the absence of microscopic, and I presume large openings, and it seems hopeless to depend on bituminous coatings. Some other coating, like cement, which is mechanical, rather than a chemical protection, against diffusion of ion into and out of the coating, seems to afford the best means in the future to protect iron surfaces. By removing the old tubercles we simply make way for new ones to form more rapidly, because the tubercle itself forms a protection which is mechanical, similar to the cement coating, due to the film action that forms on the outer crust. There is thus much reduced diffusion of the hydrogen ion into and out of that film.

W. W. Brush:[11] The origin of the iron pipe does not seem to make any difference. We have some Scotch iron pipe laid in Brooklyn about 70 years ago and a substantial amount of that pipe has been removed. We reached a very low carrying capacity in this pipe, amounting in 6-inch size to about 15% of the original capacity. A pipe 30 inches in diameter was cleaned once ten years ago, before

[11] Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

being removed, and it showed, approximately, between $\frac{1}{8}$- and $\frac{1}{4}$-inch of penetration of corrosion throughout the entire area of the pipe. The deepest pitting was a little over a quarter of an inch, and it was quite uniform.

The iron that was changed, by corrosion, was covered with tubercles, which were removed by the cleaning. The retuberculation of the pipes was rapid after the cleaning.

# THE KANSAS CITY, KANSAS, FILTRATION PLANT[1]

By C. A. Haskins[2]

The history of the Kansas City, Kansas, municipal waterworks plant during the 20 years past since the purchase of the property in 1909, has been one of continual growth and extensions, in an effort to meet the constantly increasing demands of the growing city. The city has increased from a population of 51,418 in 1900, to an estimated present population of 125,000. Kansas City has many large industries, situated mainly in the Kaw and Missouri River valleys, where ground water of fair quality is easily obtainable, but most of them have connections with the city supply for temporary or emergency use. Of course, a large number depend upon the city supply entirely. Thus large variations in demand are not unusual.

The original plant as purchased was situated on the present site, in the Quindaro district, about $2\frac{3}{4}$ miles northwest of the City Hall and adjacent to the main pumping and treatment works of the Kansas City, Missouri system. Water then, as now, was taken from the Missour River, settled, coagulated and filtered through six 1 m.g.d. Jewell, wooden tub, mechanical gravity filters. It was then lifted into the distribution system with little or no intermediate storage.

Immediately after the purchase by the city a municipal light and power plant was constructed at the same location and a development of the water purification plant began in 1911 and 1913 which furnished additional settling and coagulation basin capacity. Nine new rapid sand gravity filters of concrete construction, each with $1\frac{1}{3}$ m.g.d. capacity were added, making the total daily filter capacity 18 m.g. A 400,000 gallon clear well and a complete coagulation plant was built also.

In 1918 the Argentine reservoir was constructed on the high ground south of the Kansas River, about $5\frac{1}{2}$ miles directly across the city, south from the plant. This reservoir has a capacity of 13 mil-

[1] Presented before the Missouri Valley Section meeting, October 3, 1928.

[2] Consulting Engineer, Kansas City, Mo.

lion gallons and serves to maintain the supply in that section of the city during high rates of demand and also to reduce the variation of demand upon the purification plant. In 1923, a new coagulation and settling basin of 20 m.g. capacity was constructed at the plant, making the present basin capacity 36 m.g.

## IMPROVEMENTS AND EXTENSIONS OF 1925

The consumption has increased so greatly in recent years (average daily about 18 m.g., with maximum hourly rate of 24 m.g.d.), that new filtration capacity became imperative. In 1925, five $2\frac{2}{3}$ m.g.d. rapid sand units were constructed and a new clear well, holding 692,000 gallons. Since the completion of the new units the original filters, the Jewell wooden tub units, have been removed in order to make space for further development of the water and light plant. Thus the total basin capacity is now 36 m.g.; filtration capacity 25 m.g.d.; clear water storage at plant 1,082,000 gallons, and service reservoir storage 13 m.g.

### *Site*

The space available for this additional development was restricted, since the site is hemmed in with the Missouri Pacific R. R. on the south, joining the south bank of the river a short distance west of the plant; the Missouri River on the north, and the Kansas City, Missouri, plant on the east. A study was made, therefore, by the Department of Water and Light for the proper utilization of the entire area in order to coördinate the plans for the ultimate development of both the water works and the light and power plant.

### *Layout*

It was determined to reserve the vacant space west of the basins for future sedimentation requirements and to construct the new bank of filters to the east of and along the axis of the existing plant, designing the pipe gallery in such manner that another bank of units might be added on the east of it, back to back with the comtemplated present construction. The Jewell filters had about served their useful life and were to be dismantled and their space more adequately utilized. In this plan space for ultimate filter plant development of 55 m.g.d. could be obtained.

There were some obstructions on the area to be immediately used. The existing wash water tank, a 60,000 gallon steel structure on legs,

about 25 feet above the filters stood partially within the area and since it was too small for the new plant, it was wrecked and a new tank provided. Settling basin drains were changed and new connections made and a section of the railroad spur was relocated. Detailed plans and specifications were made and bids for construction taken in 1925 and the improvements were completed late in 1926.

### *Description*

Five reinforced concrete filters were constructed each having a capacity of $2\frac{2}{3}$ m.g.d. at the nominal rate of 2 gallons per square foot per minute. The elevation of the tops of the settling basins is 45.4 and of the existing filters 43 feet. The ground elevation is 28 to 30 feet and the 1903 high water elevation 34 feet. The difference in elevation between the basins and the filters in the existing plant necessitated frequent laborious operation of a large valve on the effluent from the basin to the filters and the high velocity through the throttled valve seemed to interfere with the floc. Consequently the new filters were built at the same level as the basins in order to keep them in balance and curbs were constructed around the tops of the existing filters so that they could all be operated at the same level.

A new 54-inch cast iron conduit was laid from the basin outlet to a connection with the influent header between new filters 2 and 3, and the piping in the new gallery was connected with the piping in the existing gallery, with 36-inch spur gear operated valves between the two on both influent and effluent lines. It was necessary to join the old and new buildings, constructed at different levels also.

### *Clear water well*

A clear water well is provided under the new filters, extending to the same depth as the floor of the new pipe gallery (elevation 18), and affording storage of 692,000 gallons. A new 48-inch cast iron suction line was laid from the high service pumping equipment to the new clear well.

### *New filters—details*

The new filters are 32 by 37 feet in plan, divided by the influent and effluent conduits into two equal parts, with a sand area of 16 by 30 feet each. Each section of each filter has 30 cast iron, tapered, lateral underdrains 16 feet long, spaced on 1 foot centers, made up by bronze welding three pieces of pipe, each 5 feet 4 inches long, the

first section 4, the middle $3\frac{1}{2}$, and the end piece 3 inches in diameter. They are so welded that the taper occurs on the inside. Each lateral is perforated with 45 $\frac{3}{8}$-inch holes on $4\frac{1}{2}$-inch centers, in a single row, turned down. The inside end is leaded into a special flange to bell casting, anchored into the conduit wall.

The far ends of the laterals rest in semi-circular notches in cast iron saddles $4\frac{1}{2}$ inches high and are thus held at a uniform distance above the floor. On account of the length of the laterals (2 feet longer than any of which record could be found) careful hydraulic tests were made on laterals of sizes and perforations in order to determine the proper taper of the laterals, and the drilling and spacing of the perforations in order to maintain the velocity head at approximately the same value throughout their length and thus to insure proper distribution of the wash water.

*Filter media*

The laterals are surrounded by 18 inches of graded gravel, ranging in size from 3 inches at the floor, to $\frac{1}{10}$-inch in size at the top. There are two feet of Red Wing sand above the gravel having an effective size of 0.4 m.m. and uniformity coefficient of 1.6.

*Wash gutters*

The wash gutters are constructed of cast iron with vertical sides 10 inches high and semi-circular bottom with 6-inch radius, calculated to carry 180 c.f.m. by the formula $Q = 2.38\ A \sqrt{\frac{A}{b}}$, where A = total cross-section and b = width. While theoretically the wash gutters could have been tapered, the manufacturer preferred to use a uniform section throughout, at the same price. The gutters are supported by bolts through a flange at the far end, extending into the wall of the filter, and they rest in the conduit wall at the other end. They are so spaced that the maximum travel of the water to reach them is $2\frac{1}{2}$ feet. The outside bottom of the gutters is 6 inches above the top of the sand. Great care was employed in erecting the troughs so that the edges were perfectly level.

*Hydraulic valves*

Each filter unit is provided with hydraulic valves for opening and closing the influent, effluent, wash, drain and rewash, operated by levers mounted on individual marble operating tables situated on the

operating floor. Each table also has an indicator for the loss of head gauge and the rate of flow gauge. The existing filters had not previously been supplied with operating tables, consequently they were also equipped with individual tables of similar appearance.

*Sampling table*

A sampling table of similar appearance is also provided with water motor operated pumps for sampling the influent from the 54-inch conduit from the settling basins and from the clear water well.

*Wash water*

A new 100,000 gallon tank, erected over the filter building, at an elevation of 45 feet above the filter bottoms furnishes wash water. It is supplied by an electric motor driven 4000 g.p.m. pump taking suction from the clear well. The filters are washed at a rate of 2 feet vertical rise of wash water per minute, or 14,400 gallons per minute per unit. A double faced gauge showing the depth of water in the clear well is provided in the gallery and another gauge shows the altitude of the water in the wash water tank.

*Control equipment*

Each filter is provided with a 16-inch Venturi effluent controller with normal capacity of $2\frac{2}{3}$ m.g.d., and an operating range of from $1\frac{1}{4}$ to $3\frac{3}{4}$ m.g.d., with a loss of head of not more than 5 inches and a variation of rate not more than 5 percent within these limits. Venturi controllers which had been omitted in the design of the existing filters, were also erected on the existing nine $1\frac{1}{3}$ m.g.d. units, of a similar type, but with an operating range of from 1 to 3 m.g.d.

*Wash water rate controllers*

Two registering, recording and indicating Venturi type wash water rate controllers were erected, one with 24-inch ends, with 7,200 g.p.m. normal capacity, with range of from 1000 to 13,000 g.p.m. for the existing filters; and one with 30-inch ends, 14,400 g.p.m. normal capacity with a range of from 2000 to 20,000 g.p.m. for the new filters. Two illuminated indicating dials are hung from the roof truss in the operating room at a point between the old and the new filters and visible from either end of the operating floor shows the rate of wash.

*Venturi meter secondary indicator*

The existing Venturi meter on the discharge line from the high service pumps to the city is situated in the pumping station in an-

other building. Consequently, an electric secondary indicator was erected in the chlorine room about 190 feet away from the meter to enable the filter plant operators to know the rate of pumpage to the city and to adjust the chlorine dosage with the varying rate. A 4-inch pressure line was laid in a circuit about the gallery and connected to an 8-inch high pressure main, equipped with pressure regulating valves to maintain constant pressures, for operating the hydraulic valves.

*Miscellaneous items*

A six ton hand driven bridge type traveling crane was erected over the pipe gallery, with a high speed, 36-foot lift, hoist.

New and enlarged laboratory quarters were provided in the second floor over one of the new units, affording a space 36 feet 3 inches by 30 feet 3 inches subdivided into a main laboratory room, a coal testing room, an office and a store room, with plumbing, lighting and heating conveniences.

The building housing the new filters and one blank space between the old and new filters, is 53 by 222 feet in plan. It is constructed of brick with a plastic gypsum roof supported by steel trusses. Provision was made for extending the building on to the north and east, to house additional filter units at some future time.

*Costs*

The entire cost of the new filter plant except for engineering, was $330,000, which amount includes the items constructed for the old filters, such as the operating tables, wash water rate controller, effluent controllers, curbs around filter boxes, etc.

ACKNOWLEDGMENT

The general contractors were Wyatt & Barcus of Kansas City, Kansas. Mr. C. T. McFarland of Kansas City, Missouri, was the filter contractor; and the control equipment gauges, and similar items, were furnished by the Builders Iron Foundry of Providence. The improvements were designed and the construction was supervised by the Water and Light Department of the City under the direction of H. C. Ackerman, Chief Designer, supervised by James D. Donovan, as Chief Engineer, Water and Light Department, and the writer as Consulting Engineer. Mr. L. B. Mangun, Chief Chemist, gave much assistance and helpful advice.

# THE PREVENTION OF CHLORO-PHENOL TASTES IN NEW YORK STATE

By Charles R. Cox[1]

Concerted effort by water purification authorities has developed practical procedures whereby water of safe sanitary quality may be provided even when the raw waters are heavily polluted. Frequently, however, the physical character of the water is unsatisfactory, due to the presence of soluble organic matter, which is not removed by the purification processes, or to the taste of residual chlorine or chlorine reaction products resulting from the necessary use of large doses of this disinfecting agent. It is evident, therefore, that methods of improving the physical character of water supplies are essential to meet the demand of the public for attractive potable water.

Many industrial wastes interfere with the processes of water purification, especially coagulation, or introduce taste producing compounds which in themselves, or after reacting with chlorine, cause obnoxious tastes in the treated water. Effort is being made by those in authority to prevent the pollution of streams by industrial wastes as far as possible, although the instigation of elaborate waste treatment processes at many industrial plants will not entirely prevent pollution. Serious study will have to be given, therefore, to new or modified methods of water purification whereby taste producing compounds present in water may be destroyed or modified.

The most difficult problem in the prevention of obnoxious tastes in water supplies has been the removal or destruction of phenolic compounds introduced into streams or lakes with wastes from by-product coke ovens. The coke oven industry fortunately has developed several successful methods of treating ammonia still wastes to remove the phenols, so the degree of pollution of the water supplies by such wastes should be less in the future. There will be occasions, however, when breakdowns will occur at such waste treatment plants, or when temporarily the efficiency of phenol recovery will be low. Every effort should be made, therefore, to continue the study of the

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treatment of wastes in order that more economical and reliable methods may be developed.

The by-product coke oven industry is restricted to the east and midwest where soft coal is available and where there is a demand for coke in steel mills. Chlorophenol tastes in water supplies, therefore, have occurred in a relatively restricted portion of the country, and comparatively little study has been given to their prevention or destruction. As is generally known, the first reported studies of this problem were those of Sir Alexander Houston of London, England, who developed three methods, namely, superchlorination followed by dechlorination, permanganate treatment, and ammonia treatment. A review of the literature indicates that these methods have been utilized on this continent as follows: superchlorination at Toronto, Ontario, and Bay City, Michigan; permanganate treatment at Rochester and Lackawanna, N. Y., and ammonia treatment at Greenville, Tenn., and Springfield, Ill.

The adsorption of phenolic compounds in water by passing the water through beds of "activated carbon" has been tried with success in Germany and the method is being studied in this country by the carbon industry, and investigators at Cleveland and Chicago. No engineering data on plant scale are available so no statement can be made relative to the feasibility of this otherwise attractive procedure on a plant scale.

We have been informed, likewise, that ozone effectively destroys chlorophenols in water. This was ascertained on a practical scale at Chicago, where many of the beverage and bottled water establishments have ozonating equipment. During the period when the chlorinated water of the Chicago water supply had a distinct chlorophenol taste, these beverage plants were able to produce attractive products, indicating the effective destruction of chlorophenol bodies by ozone.

The trial of the potassium permanganate treatment at Rochester and Lackawanna, N. Y. was recommended by the New York State Department of Health in the hope that this very flexible treatment might prove efficacious. The satisfactory results secured at these two points led the Department to recommend that similar treatment be utilized at Buffalo, Rensselaer and Waterloo, N. Y. during 1929, when chlorophenol tastes were occurring in these supplies. It was realized, however, that permanganate treatment might be unsatisfactory under the local conditions at Buffalo, so it was also suggested

that superchlorination and ammonia treatment be experimented with before attempts were made on a plant scale to prevent or remove chlorophenol tastes from this large supply. These studies were conducted jointly by the Department of Public Works of Buffalo and the State Department of Health. The results secured by these studies should be of general interest and they are, therefore, summarized here. No attempt will be made to tabulate the large amount of quantitative data collected, but the significant results are discussed.

### BUFFALO

The water supply of the city of Buffaio is secured from Lake Erie near the point of discharge of the lake into the Niagara river. Normally the water is of very low turbidity and is relatively unpolluted. During periods of strong westerly winds, however, polluted shore waters are carried toward the intake. At times these shore waters have contained appreciable quantities of phenolic wastes from two large coke oven plants in or near Buffalo. Phenol recovery equipment has been constructed recently at these plants, but during the winter of 1928–29 chlorophenol tastes appeared at intervals in the supply, so efforts were directed toward improving the physical quality of the water.

The Lake Erie water did not contain phenolic compounds at the intake during the period of the studies in January, 1929, except for a few hours on January 7, so the experiments had to be restricted to the following laboratory procedure: Measured quantities of ammonia still wastes, containing 480 p.p.m. phenol were added to 2 liter quantities of raw or filtered water, as the case may be. Very pronounced and characteristic phenol tastes were thereby produced, when the dose of phenol was 0.05 to 0.10 p.p.m. and when the subsequent doses of chlorine were 0.3 to 1.0 p.p.m. These concentrations in general are considerably higher than the minimum doses found to produce such tastes with other wastes. It was found in addition that the characteristic chlorophenol taste tended to decrease in intensity or to disappear when the treated waters were allowed to stand in bottles at laboratory temperature. Samples of tap water, collected on one occasion when the municipal water supply had a pronounced chlorophenol taste, likewise lost this taste when samples were stored over night in five gallon bottles. This apparently is one of the few reported instances where this phenomenon was observed, although it may be that similar results were observed at other points and not

referred to in available literature. It is obvious, however, that this natural disappearance of chlorophenol tastes is of great practical importance. As the tap water had been effectively chlorinated, it is doubtful whether the reduction in the content of chlorophenols was due to biochemical processes, which, however, appear to cause a reduction in the phenol raw waters, as at Rensselaer, and on the Ohio River.

*Superchlorination*

The filtered chlorinated water of the Buffalo supply on the morning of January 7, had a distinct chlorophenol taste for a few hours. This taste could be duplicated by adding 0.3 p.p.m. of chlorine to a sample of filtered, unchlorinated water. Other samples of filtered, unchlorinated water treated with 1.0 to 2.5 p.p.m. chlorine as superchlorination doses had no chiorophenol taste in one hour's time, when the residual chlorine was removed by sodium thiosulphate. These results indicate that superchlorination with doses of chlorine of 1.0 p.p.m. or greater, effectively destroyed the phenolic compounds in one hour's time, when dealing with the concentration of phenol which was actually present in the raw water entering the filtration plant at that time.

Some time later in the same day the raw water contained no phenol and it was necessary to add from 0.1 to 0.2 p.p.m. phenol in measured quantities of A-C liquor to produce the characteristic taste. Raw water so treated and superchlorinated at rates of 1.0 to 3.0 p.p.m. chlorine developed characteristic and permanent chlorophenol tastes in all samples, except that treated with 3.0 p.p.m. chlorine, which was tasteless after four hours. The most pronounced taste was found to be present in the sample dosed with 1.0 p.p.m. chlorine. These results, therefore, indicate that a superchlorination dose of 3.0 p.p.m. of chlorine effectively destroyed the phenolic compounds in *raw* water, so that a tasteless water was produced following the dechlorination reaction. *Filtered*, unchlorinated water dosed with 0.15 p.p.m. phenol developed a characteristic chlorophenol taste with 1 p.p.m. chlorine, although 1.5 p.p.m. chlorine or greater produced a tasteless water after one hour, when the water was dechlorinated. It was, therefore, observed that the superchlorination reaction was more rapid in the case of the filtered water.

The practical implication of these results is that superchlorination would be more effective when applied to filtered water than to raw

water. It would be necessary, however, at many plants to apply the superchlorination dose to the raw water to provide the necessary reaction period, and to apply sulphur dioxide, sodium thiosulphate, or sodium sulphite, as a dechlorinating agent, to the settled or filtered water. This treatment was not tried on a plant scale at Buffalo, because of cost and lack of chlorination equipment of sufficient capacity.

*Ammonia treatment*

It appears from the literature that ammonia treatment in concentrations of 0.1 to 0.2 p.p.m. when applied before the chlorine dose is effective in preventing the formation of chlorophenol compounds. This is presumably due to the fact that ammonia reacts with the chlorine very rapidly to form chloramines, which are comparatively stable and presumably do not react with phenols. Chloramines are well known disinfectants, which, being somewhat stable are less active than an equivalent dose of chlorine. The ultimate efficiency of disinfection by chloramines, however, may be higher than that by chlorine when the disinfection period is sufficient, because their disinfecting action persists for longer periods. More study of this important factor is needed before ammonia treatment can be applied with assurance to the more heavily polluted waters.

Ammonia solution was applied to *raw* Lake Erie water, containing 0.1 p.p.m. phenol, in doses of 0.1 and 0.2 p.p.m. Subsequent chlorination of the samples with 1.0 p.p.m. chlorine did not produce chlorophenol tastes, although a "control" sample containing no ammonia had such a taste. Water so treated, however, had a slight ammonia taste, which disappeared in about one-half hour. Similar results were secured when *filtered* water was treated with 0.1 p.p.m. phenol, 0.1 p.p.m. ammonia and from 0.3 to 1.0 p.p.m. chlorine, although in this case a slight chloramine taste remained in all the samples so treated, except that dosed with 1.0 p.p.m. chlorine. It will be noted that the 1.0 p.p.m. chlorine dose was 10 times the ammonia dose, and, therefore, the relative proportion of the chlorine and ammonia were roughly that necessary for the complete reaction of the ammonia and the chlorine to form dichloramine, whereas in other instances the ratio of ammonia to the chlorine doses was relatively greater. These results indicated the desirability of regulating the chlorine and ammonia dose so that these chemicals would react most completely.

Subsequent tests were made, therefore, by the addition of pre-

viously prepared chloramine to samples of water containing phenols. For this purpose 0.05 p.p.m. ammonia solution and 0.30 p.p.m. chlorine solution were added together to form dichloramine. This ratio provided a slight excess of ammonia, the theoretical quantities being 1.2 parts of ammonia to 8.0 parts of chlorine. The application of this solution of chloramine to filtered water, containing 0.05 p.p.m. phenol produced a tasteless water, although a control sample containing no ammonia had a distinct chlorophenol taste, and another sample dosed with the same concentrations of phenol, ammonia and chlorine added separately, did not have a chlorophenol taste but a slight chloramine taste. It was concluded from these results that most satisfactory results could be secured when the doses of chlorine and ammonia were carefully regulated in proportions of about eight to one, or when these chemicals were previously mixed to form dichloramine solution. The ammonia dose should be at least one-eighth the chlorine dose, otherwise nitrogen trichloride might be formed, and no disinfection would result were this the case.

Ammonia gas is very soluble in water. Thus it may be applied readily to raw, settled or filtered water *before* the chlorine dose without appreciable loss. No elaborate dosing equipment is needed, it being possible to make ammonia solution by conducting the gas in a tube from the pressure cylinder to a solution tank, a hydrometer being used to determine the resulting strength of solution. Care must be exercised to prevent water backing through the tube into the cylinder. This may be accomplished by extending the tube in a loop about 34 feet above the water surface, or above the suction limit of a vacuum. Ammonia in larger quantities also could be added directly to the water supply, scales being used to determine the loss in weight and hence the dose of ammonia. The ammonia treatment was not applied on a plant scale at Buffalo as potassium permanganate treatment appeared to be better adapted to local conditions.

*Potassium permanganate*

On January 7, when the tap water had a chlorophenol taste as stated above, potassium permanganate treatment was applied to samples of tap water in doses varying from 0.05 p.p.m. to 0.2 p.p.m. All of these concentrations of potassium permanganate led to the complete destruction of the characteristic chlorophenol tastes in 15 minutes, although in one hour and 50 minutes the taste of an untreated control sample likewise had disappeared. These very favorable results indi-

cated that potassium permanganate was effective in destroying the characteristic chlorophenol tastes due to the presence of phenolic compounds in the raw water in concentrations actually existing at Buffalo. When attempts were made to duplicate these satisfactory results with samples of raw or filtered water, to which known quantities of phenolic wastes were added, it was found that a slight bitter or astringent taste was produced in certain instances. A careful analysis of the large number of tests made with the use of potassium permanganate at Buffalo leads to the conclusion that this bitter taste was due to reaction products of chlorine and miscellaneous organic matter, as the taste was entirely unlike the characteristic chlorophenol taste. It was found for instance that no bitter taste was present when the chlorine dose was relatively low, irrespective of the potassium permanganate dose. For instance, 0.1 to 0.2 p.p.m. potassium permanganate applied 15 minutes after a chlorine dose of 0.3 p.p.m. completely destroyed chlorophenol tastes due to the presence of from 0.3 to 0.8 p.p.m. phenol, which concentrations are obviously much greater than is likely to be present in polluted water. This dose of permanganate, however, was not capable of destroying such tastes when the dose of chlorine was 1.0 p.p.m. even though the phenolic content was lower, or 0.1 p.p.m. It is evident, therefore, that the relatively large doses of phenol used in these experiments required a considerable dose of chlorine, namely, about 1.0 p.p.m. to produce the maximum taste and that the chlorophenol taste so produced was removed by the potassium permanganate, but that other taste producing chlorine reaction products were not thereby destroyed. Smaller doses of chlorine presumably did not lead to the production of large concentrations of such miscellaneous taste producing compounds, and thus the same doses of potassium permanganate were more successful.

In order to produce concentrations of phenols with the A-C liquor used in these experiments, it was necessary to use appreciable quantities of the material, because the phenolic content of 480 p.p.m. is only about one-fourth of the usual phenolic content of A-C liquors. This necessitated the addition of about four times as much miscellaneous organic matter to the samples under observation than would be present when water supplies would be polluted with equivalent quantities of phenols. It is not surprising, therefore, that miscellaneous taste producing compounds were present.

Potassium permanganate treatment was also found to be somewhat

more effective when applied preceding the chlorine dose, which indicated that this oxidizing agent more effectively destroys phenols than chlorophenol compounds. If this were universally true, it would appear that potassium permanganate treatment should be applied before the chlorine dose. As manganese compounds are likely to cause staining of clothing and toilet fixtures, it would appear likewise that this chemical should be applied to the unfiltered water, so that the reaction could be completed in the coagulation basins, thereby permitting the removal of insoluble manganese compounds by the filters.

Phenolic wastes were not present in the raw water at Buffalo during the studies for sufficient periods to determine the effectiveness of potassium permanganate treatment on a plant scale. It was finally decided, however, to ascertain the effect of this treatment upon the physical quality of the water, so potassium permanganate crystals were added to the alum being fed to the raw water by one of the dry feed alum dosing machines in concentrations of one pound per million gallons of raw water, or 0.12 p.p.m. This treatment was continued for four hours, and did not lead to any appreciable modifications in the appearance of the settled, filtered or filtered chlorinated water, and the tap water had no unusual taste. These satisfactory results, therefore, indicated that potassium permanganate could be readily added to the raw water by mixing the desired quantities with the alum being fed by the alum dosing machines. A supply of potassium permanganate was purchased and is available for use in case the raw water should contain phenolic wastes in the future.

### RENSSELAER

The water supply of the Rensselaer Water Company is secured from the Hudson river a short distance below Troy, and opposite Albany, N. Y. The river at this point is subject to pollution with phenolic compounds, due to the existence of the coke plant at Troy, and also a large amount of sewage. A phenolic waste treatment plant is in use at the coke plant, so that the degree of pollution of the river water with phenolic compounds is materially less than otherwise would be the case. It has been found, however, that when the river is covered with ice and when the water temperatures are low, chlorophenol tastes are present in the water supply at frequent intervals. This interesting relationship indicates that the absence of aeration and low temperatures prevent biochemical changes in the polluted water, and

thereby prevent the modification of phenolic compounds into tasteless products, which apparently occurs at other times.

Potassium permanganate treatment was started at Rensselaer the first part of January, 1929, and has been continued uninterruptedly since then. During the winter months when the river was frozen, the raw water was chlorinated with an average of 1.75 p.p.m. chlorine, and the filtered water with an average dose of 0.50 p.p.m. chlorine, the orthotolidine tests being used as a guide for chlorination treatment whereby 0.5 p.p.m. residual is maintained in the applied water and 0.2 p.p.m. residual in the water leaving the plant. When ice disappeared from the river this spring, the doses of chlorine were reduced to 1.25 and 0.25 p.p.m. respectively. The alum dose during the winter months was about 2.5 grains per gallon, whereas later it was reduced to 2.0 grains per gallon, even with an increase in turbidity of the raw water due to spring floods.

Doses of 0.06 to 0.10 p.p.m. potassium permanganate effectively destroyed chlorophenol tastes in the water, and incidentally improved the coagulation of the water as determined by the clarity of the filtered water and the ease of washing of the filters. The potassium permanganate dose has been added to the raw water about an hour preceding the raw water chlorine dose. Although chlorophenol tastes have been destroyed by the preliminary potassium permanganate treatment, occasionally there is a slight bitter taste in the treated water, as noted at Buffalo and Waterloo. It is difficult to state what this taste is due to because of the very complex nature of the organic matter present in the polluted Hudson river water which receives drainage from swamp lands, paper mills, sewage and other miscellaneous wastes. The doses are too small to lead to the taste of potassium permanganate itself, even were the compound to remain in the water as such.

The permanganate treatment at Rensselaer is accomplished by the use of solution feed equipment and the conventional orifice box. The chemical dissolves rather slowly, so a known weight of the chemical is dissolved in a bucket of warm water. The solution so made is utilized the following day after dilution in the solution tanks.

### WATERLOO

The village of Waterloo secures its water supply from the Seneca river which drains Seneca Lake. Phenolic compounds were discharged into the northern end of this lake near the outlet in the past

with the subsequent production of obnoxious tastes in the Waterloo water supply. A successful waste disposal plant was constructed at a by-product coke plant located at this point, which effectively stopped the serious pollution of the water supply. Drainage conditions were modified subsequently through the construction of a highway culvert permitting the discharge of miscellaneous wastes from the coke plant directly into the lake. During the early part of 1929, such drainage contained comparatively large quantities of phenolic compounds, due to breakdown of the phenolic waste disposal equipment. Pending the repairs to this equipment, potassium permanganate treatment was instituted at the Waterloo rapid sand filtration plant. Doses of potassium permanganate of between 0.06 and 0.12 p.p.m. were applied to the raw water just before sedimentation. The settled water was then chlorinated and finally filtered through rapid sand filters. This treatment effectively destroyed chlorophenol tastes, but did not destroy other less disagreeable tastes of a bitter or astringent nature, mentioned above.

Potassium permanganate, in oxidizing organic matter in water, naturally modifies the chlorine demand of the water, which is dependent primarily upon the organic content. Potassium permanganate treatment, therefore, will influence the rate of disappearance of residual chlorine in chlorinated waters and thus the orthotolidine control of the chlorination process must be accomplished with due consideration to the modifications incidental to such treatment. In addition, potassium permanganate reacts with orthotolidine to produce a false color equivalent to 1.0 to 1.3 p.p.m. chlorine for each 1.0 p.p.m. potassium permanganate. Potassium permanganate, however, is soon modified to some other manganese compound, and 1.0. p.p.m. manganese has been found to produce a false color with orthotolidine equivalent only to about 0.2 p.p.m. chlorine. An error of about 20 to 25 percent in the accuracy of the orthotolidine tests, therefore, results when potassium permanganate treatment is utilized, provided the test is applied after the permanganate has reacted. Potassium permanganate as such imparts a distinct pink color to water in concentrations of about 0.2 p.p.m. or greater. This pink color disappears quite readily, however, when the potassium permanganate reacts with phenolic compounds and organic matter and thus the color will not persist. Normally it would not appear advisable to add concentrations of more than 0.2 p.p.m. potassium permanganate to the water, and fortunately experience on a plant scale

has indicated that concentrations of about 0.05 to 0.10 p.p.m. are usually effective when conditions are suitable for this special treatment to be utilized.

## SUMMARY

It may be concluded from the above results that superchlorination or ammonia treatment is effective in destroying or preventing chlorophenol tastes, but that the potassium permanganate treatment is not universally satisfactory, due to the occasional production of secondary tastes of a bitter or astringent nature. Final conclusions cannot be drawn as to the general applicability of the permanganate treatment until more study with various types of waters containing more or less organic matter and phenolic compounds is carried out.

## CONCLUSIONS

1. Superchlorination has been found effective, although the treatment is expensive. Superchlorination, however, has the great value of effectively disinfecting the water and of oxidizing some of the miscellaneous organic matter likely to be present in waters, thereby improving the general character of the treated water.

2. Ammonia treatment, when applied before the chlorine dose, is effective in preventing the formation of chlorophenol compounds. Successful results may be secured also by the mixture of ammonia and chlorine solution before they are introduced into the water to form dichloramine, which is a relatively stable disinfectant and does not appear to react with phenolic compounds. There is necessity of careful study of the effectiveness of chlorination of ammonia treated water because it is known that chloramines are less active as disinfectants than corresponding quantities of chlorine, although the action of chloramines persist for longer periods, and thereby may have a greater ultimate effect. It would be dangerous, however, to apply ammonia treatment to heavily polluted waters unless preliminary study indicated that satisfactory disinfection is secured.

3. Potassium permanganate treatment is flexible, as it may be applied to either raw, filtered, or filtered chlorinated water. The necessary dose of 0.1 to 0.2 p.p.m. is low, and the cost of chemical of about $0.20 per pound is moderate.

4. Potassium permanganate treatment will not result in the staining of clothes, etc., judging from the experience at Rochester, Lackawanna, Waterloo and Rensselaer. It might be better, however, to

treat the raw water, as at Rensselaer, so that insoluble manganese compounds will be removed.

5. Special care must be exercised, when utilizing the potassium permanganate treatment, to compensate for its influence upon the results of the orthotolidine test for residual chlorine.

# CHLOROAMINES IN THE DISINFECTION OF WATER[1]

By Jack J. Hinman, Jr.[2] and Kenneth C. Beeson[3]

If ammonia is added under the proper conditions to a solution of a hypochlorite, such as calcium hypochlorite, a new compound is formed which has properties quite different from either the chlorine compound or the ammonia. This compound resulting from the reaction between ammonium hydroxide and calcium hypochlorite, or bleaching powder, was first investigated by Raschig (1, 2) in 1907. Analytical evidence showed the compound to be monochloroamine, $NH_2Cl$.

In 1901, Noyes and Lyon (3) studied the reaction between ammonia and chlorine and found that nitrogen, nitrogen trichloride, and ammonium chloride were the products.

$$12NH_3 + 6Cl_2 \rightarrow N_2 + NCl_3 + 9NH_4Cl$$

In their experiments with ammonium hydroxide and chlorine, Bray and Dowell (4) claim that when so much ammonia was added as to make the solution definitely alkaline, a small amount of monochloroamine was probably present. They support this statement with evidence of a reaction with starch and potassium iodide. They found that the amount of monochloroamine and the alkalinity slowly reduced when the solution was allowed to stand for forty-eight hours. Bray and Dowell present equations to support their belief that the monochloroamine is an intermediate product in the formation of nitrogen.

$$\text{(1a)} \quad NH_3 + ClO^- \rightarrow NH_2Cl + OH^-$$
$$\text{(1b)} \quad 3NH_2Cl \rightarrow N_2 + NH_3 + 3H^+ + 3Cl^-$$

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[1] Presented before the Iowa Section meeting, September 29, 1927.

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They point out that equation (1a) plus equation (1b) is equivalent to the following equation which represents the complete reaction in an alkaline solution.

$$(2) \qquad 2NH_3 + 3ClO^- \rightarrow N_2 + 3Cl^- + 3H_2O$$

The claim is also presented that the conditions under which the monochloroamine decomposes rapidly (1b) seem to correspond with the conditions under which nitrogen is formed rapidly in reaction 2. Bray and Dowell, therefore, believe that the formation of monochloroamine constitutes the very rapid primary reaction and that its decomposition is involved in the slower subsequent reaction.

The principal reason for interest in chloroamines is their high germicidal value. Disinfectants are generally standardized against carbolic acid. Rideal (5) found that chlorine gas had a carbolic acid coefficient of 2.18, and that if ammonia was added with the chlorine, the coefficient was raised to 6.36 or almost three times as great a value. If this is true under all conditions, chloroamines or chlorine-ammonia compounds should be of great value in water treatment. Taking the germicidal value of chlorine as 200 units in seeking an explanation of the high value with chlorine and ammonia one must assume the presence of a substance having a coefficient of about 600 units. Rideal (5) states that the coefficient of ammonia is less than 0.7, therefore, the compound with the coefficient of 600 units must be an entirely different compound from either chlorine or ammonia. Rideal claims further that the disinfecting power of these chlorine-ammonia compounds restrains bacterial growth for as long as seventy-two hours in some cases.

In considering the probable action of the monochloroamine on the bacterial cell, it is instructive to note the manner of action of a compound of a nature somewhat similar to that of the chloroamines, namely, para-toluene-sodium-sulpho-chloramide. This substance is more commonly known as "chloramine-T." According to Dakin (6).

It is believed that the antiseptic action of the hypochlorites is due to their capacity for attacking proteins and related bodies with formation of substances containing chlorine linked to nitrogen. The "chloramine-T" itself appears to act in the same way, for when brought in contact with proteins, such as blood serums or peptones or amino acids, it parts with its chlorine, which attaches itself to the nitrogen of the second substance. The "chloramine-T" represents an active antiseptic containing a store of chemically combined chlorine in a form which is quite stable. When brought in contact with proteins and

similar cell constituents containing basic ($NH_2$) groups, it acts as a chlorinating agent losing its chlorine to the basic substances, and thereby exerting its antiseptic action.

F. W. Tilley (7) found that ammonia added to chlorine decreased rather than increased the germicidal value of the chlorine in the absence of organic matter, but that it does tend to prevent depreciation of germicidal activity on the addition of blood serum.

B. A. Adams (8) found that ammonia added to water retarded sterilization, but that ultimately the treatment was more effective.

The influence of ammonia on the chlorination of water was noticed by Rideal (5) in 1910. He found while chlorinating some sewage that the first rapid consumption of chlorine was succeeded by a slower action which continued for some hours, or even days, and was attended by a germicidal power after free chlorine or hypochlorite had disappeared. He reasoned that the chlorine, in supplement to its oxidizing action, which had been exhausted, was acting by substitution for hydrogen in ammonia and organic compounds yielding products more or less germicidal. Rideal determined free and saline ammonia and found it to be only partially decomposed by chlorine. He believed, therefore, that ordinarily intermediate compounds were formed, that is, the chloroamines.

Probably the most important work in connection with the use of chloroamines in the sterilization of water was done by Race (9) in 1915. Race made a series of experiments using ammonium oxalate and bleach. He assumed the following reaction:

$$Ca(OCl)_2 + (NH_4)_2C_2O_4 \rightarrow CaC_2O_4 + 2NH_4OCl$$

He found that the velocity of the germicidal reaction of this solution was about ten times that of a solution of other hypochlorites of equal concentrations. He attributed this high germicidal value to the breaking down of the ammonium hypochlorite to water and monochloroamine.

$$NH_4OCl \rightarrow NH_2Cl + H_2O$$

Race then added 0.1 p.p.m. of ammonia to a bleach solution containing 0.20 p.p.m. of chlorine and found that this mixture gave as good results as 0.6 p.p.m. of chlorine only. He then tried out his experiments on a plant scale using the ratio of two parts by weight of chlorine (as bleach) to one part of ammonia. Very satis-

factory results were obtained. In this experiment 0.11 p.p.m. of available chlorine from the bleaching powder in combination with ammonia gave as good results as 0.9 p.p.m. of available chlorine when bleaching powder suspension alone was used. The cost of the process was cut from $1.12 per million gallons of water treated for the bleach treatment to $0.45 per million gallons for the bleach and ammonia treatment.

Probably the latest work on the use of ammonia in the chlorine treatment of water was done by Harold (10). He worked on somewhat the following plan: The water used was the raw water from the Itchen River which gave positive presumptive B. coli tests in 0.01 cc. and a count on agar of 2200 per cubic centimeter. Monochloroamine was prepared by the interaction of chlorine with ammonium carbonate in a solution, the final concentration of which was about 25 p.p.m. available chlorine. Dichloroamine was prepared by using half of the quantity of ammonium carbonate used in making the monochloroamine while the chlorine was kept constant. No quantities are given, but the ratio of chlorine to ammonia was from 8:1 to 4:1. Doses of 0.2 p.p.m. of available chlorine in dichloroamine and 0.3 to 0.4 p.p.m. available chlorine as monochloroamine eliminated the organisms in the unclarified water. In more highly polluted water it was necessary to increase the dose of monochloroamine to 1.0 p.p.m. of available chlorine and the dichloroamine to 0.75 p.p.m. of available chlorine. These quantities gave satisfactory bacteriological results and no tastes were noticeable. Harold offers no evidence in this paper to show that other than ordinary chlorination was taking place. He gives no data to support his contention that either dichloroamine or monochloroamine were present.

In another paper (11) Harold takes up the problem again, but the work is not conclusive, and it is very difficult to understand what he did. His first point is that, if ammonia is added to a water prior to chlorination it is possible to get different results by titration of the water with sodium thiosulfate in the presence of potassium iodide and starch in acid and in neutral solutions. The neutral solution had only a fraction of the total chlorine as available chlorine. He attempts to point out a relationship between this difference in titration values in a neutral and acid solution saying that the germicidal activity of the chlorine is increased when such a difference is shown. He draws the conclusion that a compound of chlorine which is readily split by acid is formed under these conditions.

Harold tried several methods of mixing the ammonia and chlorine solutions and finally came to the conclusion that by pouring the ammonia into the water first and then pouring the chlorine into the somewhat diluted ammonia was the best method. He believed that it was a matter of the diffusion of a strong chlorine solution through a less concentrated ammonia solution. In his work, Harold found that the ratio $Cl_2:NH_3::2:1$ showed equal quantities of available chlorine in acid and neutral solutions, and also the best germicidal results.

Harold credits the greater germicidal power of the chloroamines to the reaction of the NH or $NH_2$ group with the cellulose and chitin. He admits that it is necessary for a colloidal material to be present before the reaction can be successful. He says that if ammonia is added to a solution of chlorine the germicidal velocity is diminished, but if a colloid is present the velocity is increased. He believes that the colloid acts electro-negatively, dampening the effect of the energy of the chemical reaction and favoring the production of chloroamines. All of this work was done on an unclarified water, heavily polluted, but he gives no analytical data showing the exact condition of the water. From what we know of his work, it is not reasonable to draw the conclusion that the method proposed would be applicable to all waters. No appreciation of the effect of nitrites and similar substances on the acid filtration is evident.

In practice the use of chloroamines has been confined to the compounds formed from bleach and ammonia. The first to try chloroamine treatment was Race (9), who, in 1915, conducted a series of experiments and obtained such excellent results that he began treating the water of the Ottawa River on a plant scale. The amounts of bleach and ammonia were controlled from dosing tanks and mixed about eight feet away from the raw water intake (12). This reduced the period of contact of the two solutions to a minimum. He found (13) that when the mixture was used there was a loss of available chlorine amounting to only 1.4 to 3.2 percent, while from a bleach solution alone from 35 to 60 percent of the chlorine was lost.

In treating the water of a swimming pool Race (14) found that 3 p.p.m. of available chlorine did not reduce the bacterial count, but that 0.5 p.p.m. of ammonia and 1 p.p.m. of chlorine in bleach reduced the count of from between 50,000 per cubic centimeter and 100,000 per cubic centimeter to less than 100 per cubic centimeter with no B. coli in 10 cc. He found also that there were no aftergrowths in the water following the treatment which fact he attributed

to the non-absorption of the germicide and its consequent effective concentration over long periods. Olszewski (15) also found that chloroamines were very effective in treating the water of swimming pools because of the effectiveness of the residual action.

At Denver (16) bleach and ammonia were used successfully to prevent aftergrowths in reservoirs. The number of bacteria dropped from 15,000 to 10 per cubic centimeter and no aftergrowths of the bacteria resulted even in passing the water through a ten mile conduit. In the summer (17) when large numbers of plankton were present in the raw water, less ammonia was required than in the winter.

Monfort and Barnes (18) used chloroamines successfully to combat crenothrix growths. They found that for this purpose the concentration should not be greater than 1.0 p.p.m. of available chlorine, and the solution should be made up fresh every day. In their experiments 800 cc. samples of water treated with 0.5 to 1.0 p.p.m. of available chlorine as chloroamine showed no crenothrix growths at the end of seven days while control samples had heavy reddish growths of the organism. There were no offensive tastes produced except in the samples having the larger amounts of chloroamines.

Chloroamine made from a 2.5 percent solution of bleach and a 0.22 percent solution of ammonia was used by Hale (19) in treating the Catskill water. A concentration of the mixture containing 0.05 p.p.m. available chlorine removed 93 percent of the Bact. coli which existed in the untreated supply.

McAmis (20) used the ammonia-chlorine process to combat tastes. He added ammonia to the raw water and liquid chlorine to the filtered water. No tastes developed, but he found that sterilization was retarded, and that it was necessary to allow a greater contact period than otherwise would be required. Enslow (21), therefore, recommends that the chlorine should be added prior to coagulation if the necessary time for contact cannot be obtained after filtration.

In some experiments not yet published Kenneth C. Armstrong, chemist at the Metropolitan Utilities Laboratory at Omaha, Nebraska, added a mixture of chlorine and ammonia to the filter effluent just before the water entered the clearwater basin. The ammonia was added to the solution hose from the chlorine machine. He used from 0.44 to 1.01 pounds of ammonia per million gallons of water and 3.02 to 3.56 pounds of chlorine. The results obtained were practically identical with those obtained when from 3.32 to 3.68

pounds of chlorine were used alone. This series of experiments extended from April 8, 1927 to April 21, 1927. Similar results were obtained in an earlier set of experiments in the summer of 1926.

## EXPERIMENTAL DATA

While the liquid chlorine method of treating water is very efficient in most cases, there are two conditions under which the treatment is not entirely satisfactory. The first of these is met when objectional odors or tastes develop through the formation of chloro-phenol compounds or other chloro addition compounds. The second objection is that in the presence of certain types of organic matter chlorine is lost within a short time after application through combination with the organic material. As a result of the reduced quantity of chlorine available for action on the bacteria, aftergrowths are likely to appear.

Chloroamines formed from a hypochlorite, such as chloride of lime or bleach, and ammonia eliminate both of these difficulties; but bleach is now seldom used in the chlorination of drinking waters. The question arises whether ammonia or its compounds can be used to advantage with liquid chlorine? The purpose of this work is to find out if the germicidal efficiency of chlorine is increased by using ammonia or its compounds, and, if so, under what conditions will this efficiency be the greatest.

In conducting the experiments 2 liters of water were put into each of from four to six glass stoppered, two and a half liter, acid bottles. About 5 cc. of a broth culture of Bact. coli, or 100 cc. of the sewage were added the day before the experiment was started so that the bacteria could become accustomed to the medium. Just before beginning the treatment, plantings of 1 cc. of the untreated water in petri dishes were made in agar medium for estimating the number of bacteria originally present. Whether ammonia or ammonium chloride was used, the method of treatment followed was the same throughout the entire group of experiments. Since Harold (11) in his experimental work found that the best method of treatment was to pour the ammonia into the water and then to allow about ten seconds to pass before adding the chlorine, this was the procedure adopted and closely followed. After adding the chemicals the contents of the bottles were thoroughly mixed and 1 cc. quantities of the water were removed and planted.

Free ammonia was determined on each sample before treatment

with the chemicals, and again two hours after treatment had been carried out. The other nitrogen determinations, the determination of chlorides, oxygen consumed, iron, and total solids were made on the water used in each run.

TABLE 1

*Distilled water with a broth culture of Bact. coli*

| $NH_3$ ADDED | BACTERIA PER CUBIC CENTIMETER | CHLORINE, 0.20 P.P.M. Time of exposure: 0 minutes | 15 minutes | 30 minutes | 60 minutes | 120 minutes | 24 hours | 48 hours |
|---|---|---|---|---|---|---|---|---|
| | | Bacteria per cubic centimeter | | | | | | |
| *p.p.m.* | | | | | | | | |
| None | 3,300 | 0 | 0 | 10 | 25 | 1 | * | * |
| 0.05 | 1,700 | 2,600 | 2,760 | 1,700 | 325 | 250 | * | * |
| 0.10 | 4,500 | 6,300 | 2,400 | 350 | 140 | 3,600 | * | * |
| 0.13 | 5,000 | | 270 | 460 | 610 | 380 | * | * |
| 0.20 | 4,700 | 510 | 200 | 110 | 360 | 400 | * | * |
| 0.40 | 3,500 | 500 | 450 | 500 | 250 | 370 | * | * |

TABLE 2

*Water from the Milwaukee Railroad softening plant. Vermilion River water treated with lime and soda ash and settled with sulfate of iron as a coagulant*

| $NH_4Cl$ ADDED | BACTERIA PER CUBIC CENTIMETER | CHLORINE, 0.2 P.P.M. Time of exposure: 0 minutes | 15 minutes | 30 minutes | 60 minutes | 120 minutes |
|---|---|---|---|---|---|---|
| | | Bacteria per cubic centimeter | | | | |
| *p.p.m.* | | | | | | |
| None | * | * | 2,400 | 76 | 1,600 | * |
| 0.2 | * | * | 1,200 | 38 | 550 | * |
| 0.4 | * | * | 95 | 27 | 0 | 30 |

* Indicates a crowded plate, the bacteria being too numerous to count.

A large number of experiments were carried out, but for the purposes of this paper only four typical experiments are reported in detail. The findings are shown in tables 1 to 4.

## DISCUSSION OF RESULTS

Many difficulties were encountered in undertaking this work. Among these the determination of free chlorine while conducting the experiment was probably the greatest and most annoying. At first

an attempt was made to determine the chlorine in both a neutral and an acid solution by means of potassium iodide and starch. The quantities of chlorine used were, however, too small to allow a titration

TABLE 3

*University of South Dakota well water with 5 percent sewage*

This water had a decided turbidity

| NUMBER | $NH_4Cl$ ADDED | BACTERIA PER CUBIC CENTIMETER | CHLORINE, 0.2 P.P.M. — Time of exposure — Bacteria per cubic centimeter: 5 minutes | 15 minutes | 30 minutes | 60 minutes | 120 minutes | 24 hours | 48 hours |
|---|---|---|---|---|---|---|---|---|---|
| | *p.p.m.* | | | | | | | | |
| A | None | 1,960 | 2,200 | 55 | 34 | 30 | 9 | 17 | 11 |
| B | 0.1 | 780 | 44 | 27 | 33 | 21 | 21 | 13 | 3 |
| C | 0.2 | 760 | 45 | 3 | 16 | 25 | 0 | 16 | 4 |
| D | 0.4 | 800 | 17 | 28 | 18 | 30 | 36 | 13 | 6 |

| | AMMONIA NITROGEN A | B | C | D |
|---|---|---|---|---|
| | *p.p.m.* | *p.p.m.* | *p.p.m.* | *p.p.m.* |
| Originally present | 0.048 | 0.048 | 0.048 | 0.048 |
| Added | 0.000 | 0.026 | 0.052 | 0.104 |
| Total | 0.048 | 0.074 | 0.100 | 0.152 |
| Present after two hours | 0.048 | 0.084 | 0.108 | 0.148 |

*Analytical data*

| | P.P.M. |
|---|---|
| Total organic nitrogen | 0.290 |
| Nitrite nitrogen | 0.010 |
| Nitrate nitrogen | 0.0 |
| Oxygen consumed | 1.19 |
| Iron | 0.60 |
| Albuminoid nitrogen | 0.008 |
| Chlorides | 47.0 |

to be satisfactorily conducted even with very dilute solutions of sodium thiosulfate. Colorimetric methods were resorted to, but they failed because it was impossible to get consistent colors. It was not possible to prepare standards as often as necessary during the three hours the experiment was being conducted. The ortho-

tolidine method was finally used, but almost always a lapse of from thirty minutes to an hour was necessary before the full or maximum color was developed. This suggests interference by nitrites or

TABLE 4

*Water from the Vermilion city wells with 5 percent sewage*

This water had a decided turbidity

| NUMBER | $NH_4Cl$ ADDED | BACTERIA PER CUBIC CENTIMETER | CHLORINE, 0.2 P.P.M. Time of exposure: 5 minutes | 15 minutes | 30 minutes | 60 minutes | 120 minutes | 24 hours | 48 hours |
|---|---|---|---|---|---|---|---|---|---|
| | | | Bacteria per cubic centimeter | | | | | | |
| | *p.p.m.* | | | | | | | | |
| A | None | 4,300 | 5,400 | 1,350 | 840 | 190 | 26 | 14 | 55 |
| B | 0.6 | 3,600 | 4,800 | 1,080 | 300 | 28 | 38 | 19 | 132 |
| C | 0.9 | 5,400 | 840 | 440 | 162 | 21 | 53 | 25 | 1,800* |
| D | 1.2 | 7,200 | 660 | 200 | 210 | 6 | 26 | 26 | 244 |

| | AMMONIA NITROGEN A | B | C | D |
|---|---|---|---|---|
| | *p.p.m.* | *p.p.m.* | *p.p.m.* | *p.p.m.* |
| Originally present | 0.428 | 0.364 | 0.560 | 0.510 |
| Added | 0.000 | 0.157 | 0.235 | 0.313 |
| Total | 0.428 | 0.521 | 0.795 | 0.823 |
| Present after two hours | 0.460 | 0.470 | 0.700 | 0.990 |

*Analytical data*

| | P.P.M. |
|---|---|
| Total organic nitrogen | 0.610 |
| Albuminoid nitrogen | 0.138 |
| Chlorides | 6.0 |
| Oxygen consumed | 3.27 |
| Nitrite nitrogen | 0.050 |
| Nitrate nitrogen | 0.3 |
| Total solids | 403.0 |

* Probably contaminated plate.

other substances. The chlorine determinations are, therefore, not included; but are left for future study.

Difficulties of technic were generally remedied with experience,

and for the most part the details of the work were quite simple and routine.

Experiment I was conducted using distilled water to which had been added a broth culture of Bact. coli. Six samples were treated with amounts of added ammonia varying from none to 0.4 p.p.m., and to each sample was added 0.20 p.p.m. of chlorine. The organic content of the water was, of course, practically nil, and there would be practically no colloidal material present. The results indicated (table 1) that the only sample to show efficient disinfection was the one to which no ammonia had been added. The sample containing 0.2 p.p.m. of ammonia gave fairly good results.

A natural water containing a considerable quantity of organic material was used in Experiment II. The sample treated with 0.2 p.p.m. of chlorine alone, and the one treated with 0.2 p.p.m. of chlorine and 0.4 p.p.m. of ammonium chloride gave remarkable reductions in fifteen minutes and showed no bacteria present at the end of an hour (see table 2).

In Experiment III using a 5 per cent dilution of sewage, all of the samples treated with both ammonium chloride and chlorine showed more rapid germicidal action than the one treated with chlorine alone. After fifteen minutes, however, all of the samples showed about the same degree of disinfection. The data appear in table 3.

In Experiment IV a water of much greater pollution was used and a more rapid disinfection is shown in those samples treated with ammonium chloride and chlorine than in the one treated with chlorine alone, and the efficiency increases with the increase in the dose of ammonium chloride. The results after two hours, however, show an equal disinfection in all cases, as appears in table 4.

## CONCLUSIONS

1. The addition of ammonia with chlorine in the chlorine treatment of water retards the disinfection when the water has a low organic content and when it is clear.

2. If the quantity of chlorine added is greatly in excess of that of the ammonia, the final efficiency is not hampered in a clear water of low organic content.

3. If the quantity of chlorine is small, so as to be just enough to disinfect a clear water of low organic content, the final disinfecting efficiency when ammonia is added to such water is never as great as it is with the chlorine.

4. In turbid waters of high organic content, the addition of ammonia invariably increases the germicidal velocity of the chlorine, although aftergrowths do not always seem to be prevented.

5. There seems to be no loss of free or saline ammonia during the period of contact under the conditions of these experiments.

6. From these data it is not possible to determine definitely what ratios of chlorine to ammonia are most effective, but in turbid waters of high organic content the ratios of $Cl_2:NH_3::1:2$ and $1:3$ seem always to give very satisfactory results.

7. The chlorine-ammonia method may be recommended in cases when it is necessary or desirable to treat raw, unfiltered waters, especially if long periods of detention after chlorination and before the water reaches the consumer are available.

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## GROUNDING OF ELECTRIC LIGHTING CIRCUITS ON WATER PIPES

### Resolution of the Executive Committee

**The Executive Committee of the American Water Works Association hereby endorses the general attitude taken by the official representatives of that Association regarding Grounding of Electrical Circuits on Water Pipes in:**

**1. Objecting to the use of water pipe systems as conductors of electric current and the transfer of any substantial part of the possible life and property hazard attending the operation of an electrical system from the system where it originates to a water piping system.**

**2. Objecting to the interpretation of water works sanction of the protective grounding of secondary electric distribution systems on water pipes as a license for the indiscriminate use of the piping system for electrical purposes, or as a current carrying part of the electric system.**

**3. Objecting to all forms of electrical construction such as common neutral, and conduit neutral, which by their nature facilitates the escape of current from the electrical system to house pipes and the water distribution system.**

**4. Requesting American Water Works Association representation on the Electrical Committee of the National Fire Protection Association.**

**It also specifically approves its representatives' letters of March 16, 1929[1] and of July 23, 1929[2] to the National Fire Protection Association.**

**Passed, September 9, 1929.**

**July 23, 1929.**

**Mr. A. R. Small, Chairman,**
**Electrical Committee,**
**National Fire Protection Association,**
**109 Leonard Street,**
**New York, N. Y.**

**Dear Sir:**

**Through Mr. G. W. Booth, Chief Engineer of the National Board of Fire Underwriters, we have just been advised that the use of a bare neutral con-**

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[1] Journal, June, 1929, page 828.

[2] This Journal, page 1717.

ductor in metallic conduit has been proposed for buildings and that installations of this character have been made in Evansville, Indiana and in several other cities of the Middle West. As representatives of the American Water Works Association, speaking for the water works interest we would point out that such installations by their very nature not only violate one of the basic stipulations embodied in the American Water Works Association resolution sanctioning the grounding of secondary electric lighting circuits on water pipes but that they are fundamentally contrary to all generally accepted safety principles involved in the operation of electric light and water works system.

Water works operators of course do not own the house piping systems, but they do exercise supervision and control over all attachments to their distribution system and any method of electrical construction which makes the house water pipes and incidentally the water distribution system a current carrying part of an electrical circuit is objectionable to the water works operator on account of the life and property hazard attaching to electric current flow over piping systems not designed for such use. With the endorsement of the Executive Committee of the American Water Works Association, we would therefore place this Association on record as being unqualifiedly opposed to the bare neutral type of electrical construction and as requesting that the Electrical Committee give no sanction to this type of construction.

At the present time, the water works interests whose structures are being used to safeguard life and property against electrical hazards resulting from the operations of other utilities, are not represented on the Electrical Committee or its Grounding Sub-committee but must depend upon indirect contacts for information and action regarding changes in electrical construction methods which may have a vital bearing on the general safety of water pipe systems. We believe this arrangement has always been improper and irregular and recent developments in the electrical distribution field demonstrate the desirability of Water Works representation upon the Electrical Committee. For this reason, and with the expressed endorsement of the Executive Committee of the American Water Works Association, we respectfully request official representation for this Association on the Electrical Committee of the National Fire Protection Association.

Respectfully submitted,

Nicholas S. Hill, Jr.,
Edward E. Minor,
Chas. F. Meyerherm,
*Representing American Water Works Association.*

# Albert E. Walden

### Born, August 18, 1872, died, August 26, 1929

Albert E. Walden, for many years a member of this Association, died suddenly on August 26, 1929. Although in poor health for sometime Mr. Walden's death came as a great shock to his many friends and engineering associates.

He had resigned only recently as Chief Engineer of the Metropolitan District of Baltimore County and it was the hope of his friends and associates that he would regain his impaired health.

Mr. Walden was born at Rockland, Maine, August 18, 1872 and received his early education and engineering training with the Rockland & Thomston Gas & Electric Light Company and later with the Edison Company in the construction of the Plant for the Rockland Thomston & Camden Street Railway. He was associated closely in the early development of the electric lighting field with a number of companies in New England. For two years he was employed by The Elmira Water Light & Railway Company at Elmira, New York. Later he was with the Mobile Light & Railroad Company, Mobile, Alabama, The Freeport Light & Railroad Company, Freeport, Illinois and the Calumet Light Company, acting in capacity of Superintendent and Chief Engineers in these various enterprises. For a time he was associated with Dodge & Day, Consulting Engineers and with the Stevens Engineering Company.

Possibly Mr. Walden was best known in the engineering profession as Superintendent and Chief Engineer for the Baltimore County Water & Electric Company, serving in this capacity from 1906 to 1921. During this period he constructed and operated all the engineering projects of the above Company and designed and patented a number of engineering appliances. The portable standard test meter for testing water meters in place, designed by Mr. Walden, has been used by many companies and public service commissions. He received also wide recognition for his work in the design and operation of a water purification system employing ozone as a sterilizing agent.

After the sale of the property of the Baltimore County Water &

Electric Company to Baltimore City, Mr. Walden was retained for two years to operate the system until it was placed under the supervision of the Baltimore City Water Department. From May 1, 1924 until April 12, 1929 he served as Chief Engineer of the Baltimore County Metropolitan Commission and through his energy and untiring efforts the extensive work of this commission was carried forward. His work included organizing and supervising the engineering work of the Commission which included the expenditure of over $4,000,000 for the construction of approximately 150 miles of water mains and 80 miles of sewers and automatic booster pumping stations.

He was an active member of the American Society of Mechanical Engineers, the National Electric Light Association and the Engineers Club of Baltimore and a number of other engineering societies. He was intensely interested in all matters pertaining to engineering progress and development and took great interest in assisting young engineers. Much credit is due to Mr. Walden for his pioneer work in the establishment of vocational training in the school systems in Baltimore. He was untiring in his effort to arouse the city officials and educators to the desirability and advantage of this type of training in the public school system.

Mr. Walden is survived by his widow, two sons and a granddaughter.

S. T POWELL.

## Charles Henry Ade

### Died, September 18, 1929

Charles Henry Ade, of San Antonio, Texas, Southwestern Manager for the National Meter Company, died on September 18, 1929 after a brief illness, at Easthampton, Connecticut.

Mr. Ade was 65 years of age, and had been identified with the National Meter Company for over twenty years. He was a member of the Rotarian and other good-will organizations, and one of the Directors of the South West Water Works Journal. His genial personality, unfailing good spirits, and sincere friendliness made him one of the most popular figures of the "road," as well as in his own home town. He will be greatly missed.

Mr. Ade is survived by a widow, and one daughter, the child of a former marriage.

# Daniel Kennedy

## Died, January 14, 1929

Daniel Kennedy, President of The Kennedy Valve Manufacturing Company, died at Hot Springs, Arkansas, on January 14, 1929 after a short illness.

Mr. Kennedy was in his eightieth year. He came to America from Ireland as a youth of seventeen. In the trade as well as in his home city, he was highly esteemed and a leading industrial figure. He originated and for half a century guided a firm that was a pioneer and leading builder in the valve, fire hydrant and pipe fittings field.

Mr. Kennedy's first business venture was in connection with the old Boston Dry Dock built in the Erie Basin, Brooklyn, N. Y., in 1877 and now owned by Robbins Dry Dock & Repair Co.

The valve equipment for controlling the flow of water in and out of this dock was an important factor in its operation. In competition with designs submitted by valve builders of that period, those of Mr. Kennedy were chosen, and he was awarded the contract for building the gate valves in sizes ranging from 48-inch down, conditioned upon making the installation within given time and assuring successful performance. These valves, located at the bottom of a 35-foot pit, were placed on time, met every requirement and even today are still functioning perfectly and to the entire satisfaction of engineers now in charge.

The steady conservative growth of The Kennedy Valve Manufacturing Company was the consistent reward for Mr. Kennedy's tireless energy, ambition, natural resourcefulness and scrupulously honest dealing.

Many valves and fire-hydrant design features of the now accepted general standards were originated by Mr. Kennedy.

Mr. Kennedy's primary interests were in his family and in his business, to both of which he was conscientiously devoted. In private life he was of a retiring disposition and had an abundance of sterling qualities. His philanthropies were innumerable, but were carried out anonymously and with the reserve that was charateristic of the man. With his hundreds of employees, he enjoyed that popularity which is invariably courted by men in his position, but is often lacking. He knew many of his men personally, called them by

their first names, and lived to see many of the sons and even grandsons of oldtime employees grow up in the business.

Besides his widow Mr. Kennedy is survived by three sons, Matthew E., J. C. and Clarence H., Treasurer and General Manager, Works Manager and General Sales Manager respectively of the Kennedy Valve Mfg. Co., and by three daughters, Mrs. John C. Judge of Brooklyn, N. Y., Mrs. Alexander H. MacCreery of Tulsa, Okla., and Miss Kathleen Kennedy of Elmira.

## George H. Snell

### Died, April 1, 1929

George H. Snell, aged 64, died on April 1, 1929, following an attack of pneumonia. He was responsible in a large measure for the development of the Attleboro, Mass., water supply system.

He was born at Westport, Mass., March 29, 1864 and received his early education in the schools there, later finishing his schooling in Fall River.

He developed a pipe coupling and tee which won favor among plumbers and contractors and which is now standard equipment used by many gas and water distributing companies. He also invented a rainbow gasket to fit onto his couplings and this won wide favor not only in New England but elsewhere in the country. He also manufactured castings and structural iron.

In 1887 Mr. Snell was elected water commissioner and superintendent of water supply in Attleboro and served in this capacity for a period of many years. In that period much was done to increase the capacity of the pumping system and perfect its efficiency.

He has served as a director in the Savings & Loan Association, the Coöperative Bank and the Steam & Electric Company. He was a member of the New England and the American Water Works Associations.

He is survived by his widow, Mrs. Ida Snell, who is a native of Burlington, Me.

# ABSTRACTS OF WATER WORKS LITERATURE[1]

## Frank Hannan

**Key:** American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

**Typhoid Fever Epidemic in Fort Wayne, Indiana, Due to Dual Valve Connection.** Ruth C. Sturtevant. Amer. Jour. Public Health, 19: 9, 144, September, 1929. A dual water supply system of the Wabash Railroad at Fort Wayne, Ind., was responsible for an outbreak of gastroenteritis and typhoid fever in February and March, 1929. The railroad secured an auxiliary industrial supply from a nearby river. A gate valve on the main connecting this river supply system with the city mains was left open, permitting the discharge of polluted river water into the distribution system. There was no check valve on this cross connection. The people living in the vicinity complained of turbid water of unpalatable character on February 26. From twelve to twenty four hours later a large number of gastroenteritis cases developed characterized by intense diarrhoea, vomiting, pain and extreme weakness. On March 22 the first typhoid fever cases were reported, the last case being reported on May 11. In all, fifty-three cases and three deaths occurred. The Indiana State Board of Health prohibited such cross connections on June 1, 1924, and at the time a city-wide search was made for such cross connections but unfortunately this one was not located. It is significant to note that a similar outbreak occurred in 1923 in Fort Wayne due to the existence of a cross connection on the property of the Pennsylvania Railroad, at which time 147 cases and 20 deaths occurred. Following the recent epidemic, a thorough search has been made for cross connections in the city and many such cross connections have been located although they were not in use. They have since been eliminated. —*C. R. Cox.*

**Nashville's New Filtration Plant.** George Reyer. The American City, 41: 3, 93–94, September, 1929. A modern rapid sand filtration plant is being constructed by the city of Nashville, Tenn. Designed rate of flow is 28,000,000 gallons per day. Plant consists of a grit chamber, mechanical mixing basins, sedimentation basins, filters, and clear water basin. The grit chamber pro-

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

vides a detention period of thirty minutes at designed rate of flow; large particles of sand and grit are deposited in this basin. Twelve mixing basins, 42 feet long by 25 feet wide and 17 feet deep, are so connected as to operate either in parallel, or as a group of six pairs. These basins provide a forty-minute detention period at designed rate of flow and mixing velocity of about 0.8 feet per second is secured by motor driven paddles. Special care has been exercised in design of conduits and basins to prevent eddying and short-circuiting. A stilling chamber is placed at entrance end of sedimentation basins, by the use of a perforated wall. A designed velocity of 1 foot per minute is provided in these basins. Twelve rapid sand filter units, with a capacity of 2½ million gallons each are utilized. These are fitted with the so-called false bottom collecting system, which consists of a reinforced concrete false bottom located 21 inches above floor of filter unit and perforated at 6-inch centers with ⅜-inch brass nipples, into which umbrella type brass strainers are screwed. Eighteen inches of gravel and 30 inches of sand of the conventional size are utilized. The clear water basins are located under each group of filters and provide storage period of sixty minutes at designed rate of flow. The principal storage facilities, however, consist of the existing 50,000,000-gallon reservoir located in the heart of the city. Dry feed lime and alum dosing equipment is used and equipment for chlorinating the filtered water is also provided. An unusual feature in the design is the placing of baffles in collecting conduit at point where chlorine dose is applied, to insure thorough mixing of water with chlorine. Another somewhat unusual feature is provision of wash water tank at a considerable elevation, so as to provide an available pressure of 20 pounds per square inch at filters. Rate of wash water flow is adjusted by conventional controller to 15 gallons per square foot per minute. Each filter is provided with a rate controller and these, in turn, with a master controller, making regulation of the total quantity of water being filtered convenient.—*C. R. Cox.*

**Regulations for Water Taps and Services. Part I.** C. Kelsey Mathews. The American City, 41: 3, 95–7, September, 1929. This is the first part of a series of abstracts made by the American City of pamphlets issued by municipal water departments and private companies relative to the above subject.—*C. R. Cox.*

**Hagerstown Water-Works Safe from Flood.** Albert Heard. The American City, 41: 3, 121–2, September, 1929. The city of Hagerstown, Md., has recently completed a modern rapid sand filtration plant and the necessary intake structure on the Potomac River near Williamsport, about 7½ miles from city. The Potomac River at this point varies in elevation about 32 feet, so intake structure had to be constructed accordingly. A concrete intake was constructed along banks of river with boom for protection against ice and drift. A concrete tunnel was built from intake to a suction well, the water being piped through the tunnel in two 30-inch cast iron pipes in order to secure higher velocities than would occur were the full size tunnel utilized. Pump pit, 48 feet in diameter and 48 feet deep, contains three DeLaval motor-driven centrifugal pumps together with other smaller pumps. A mixing basin with designed period of thirty-five minutes is provided with "over and under" wooden

baffles. Two coagulating basins with designed period of three hours are also utilized. Ten rapid sand filter beds, with a capacity of 1,000,000 gallons per day each, are used. An unusually large clear water basin with capacity equal to three hours pumpage is provided under these filters. Flood protection is secured by an earthen embankment 12 feet high surrounding the entire plant. An emergency sump has been built to take care of back water from the waste drain, sump pump being driven by gasoline engine provided for use in case electric power should fail. Plant complete cost approximately $600,000.—*C. R. Cox.*

**Is Water-Meter Maintenance a Necessary Evil?** J. H. Mullison. The American City, **41**: 3, 140–2, September, 1929. Description of the system utilized by the Kansas Water Company in installation, supervision, and testing of meters owned by the Company. A very complete system of records and card indexes is utilized covering about 25,000 meters and, it is stated, maintained by a single clerk in about one-half of his working time.—*C. R. Cox.*

**A Survey of Water-Meter Rates in the United States. Part IV.** The American City, **41**: 3, 167–173, September, 1929. This is part four of a survey of water meter rates secured from statistics published in The Municipal Index for 1929.—*C. R. Cox.*

**Economic Diameter of a Pumping Main.** Chas. F. Lapworth. Water and Water Engineering, **31**: 365, 199–202, May 20, 1929. The author after discussing his mathematical study of this subject concludes that the economic velocity through a pumping main, generally speaking, is between 2¼ and 3¼ feet per second, being greater for the larger quantities and the smaller number of daily pumping hours; the economic diameter is independent of the main length; it is better to err on the large, rather than on the small side, in choosing a main size; and a wide range of prices has little effect on the solution.—*Arthur P. Miller.*

**City of Birmingham Water Department—History of the Undertaking.** Anon. Water and Water Engineering, **31**: 365, 202–207, May 20, 1929. History of Birmingham water supply from earliest attempt to provide water, in 1808, up to 1914, when funds were authorized to build Elan Valley Works. The watershed is hilly, rocky country, surface rights of which are owned by Corporation of Birmingham. Population on watershed is under 200. Six impounding reservoirs are planned; three have been built on River Elan. From storage reservoirs, water passes through mile-and-a-quarter tunnel to 30 rough sand filters with area of 2¾ acres. Present rate of filtration is about 2,000 gallons per square yard per day, but ultimate rate will be three times as great. After filtration, a small amount of alkali is added to prevent any action on lead pipes in the supply system. The author describes in some detail power works, afforestation on watershed, the 73½-mile aqueduct with its 11 siphons passing over the larger valleys, and two additional storage reservoirs located closer to point of distribution. A small reservoir originally built to supply water to construction village at Caban Reservoir, has been adapted for research work on hydraulics.—*Arthur P. Miller.*

**Birmingham Waterworks—More Recent Developments.** J. W. WILKINSON. Water and Water Engineering, **31**: 365, 208–212, May 20, 1929. This article first discusses rainfall on the Birmingham watershed which has been found to be over a long period 67.2 inches per annum. Valuable data are being collected by means of weirs installed on one of the unfinished dams on dry weather flow of streams feeding water supply system. Information is also presented on flood records over the Caban Dam. Some experimental work has been done on treatment of this water. For a short period it was treated with lime at rate of 0.75 grain per gallon, but later powdered chalk was substituted in the amount of 1 to 1½ grains per gallon. From the chalk, insoluble matter was deposited in the aqueduct. The pH of the raw water varies from 5.4 in winter to 5.9 in summer. With the use of chalk, the pH was not steady but averaged about 7.5. In 1923, silicate of soda was used in place of chalk at rate of 0.55 to 1.0 grain per gallon. This reduced corrosion and maintained a steadier pH at 6.8, which, however, was ineffective to prevent corrosion of cast iron and steel mains in siphons. Additional study indicated that pH of 8.0, necessary to prevent this, could not be economically attained by use of silicate of soda. Return was therefore made to treatment with hydrated lime, which is now added at rate of 0.42 grain per gallon. The pH now varies but little, being about 8.3. In 1912 it was recognized that additional water supply was necessary and three schemes considered, of which one calling for an additional line of pipes from gathering grounds in Wales was adopted. This main, however, was not installed until after the war and then only bit by bit as was needed to maintain the supply which was subject to frequent interruption by bursts on the two old mains. These breaks were found to occur mostly after long dry spells, and have been attributed primarily to shifting of the earth loading over them because of deep cracks developed under the dry conditions. This trouble forced the development of a concrete cradle around lower half of each pair of pipes and also caused the installation of 32 cross-connections between the two old mains. In view of this trouble with bursting mains, writer suggests that proper bedding of large cast iron pipes is of importance equal with that of their quality and thickness. Article includes a discussion of different types of pipe used in new main laid after the war. Scraping and cleaning of the corroded cast iron mains on the Elan aqueduct have been undertaken since 1921. After some twenty years of use, material to the quantity of four tons per mile has been removed from a pipe 42 inches in diameter. The advantage, after 12 months of scraping and cleaning these aqueducts, is questioned by the writer, because against the gain represented by increased flow must be balanced the loss in normal flow during cleaning operations. What is needed badly is a form of pipe coating which can be applied after the cleaning work to prevent further corrosion. The article is closed with discussion of new type of automatic inlet and construction work on new Bartley reservoir.—*Arthur P. Miller*.

**A Novel Australian Pumping Plant.** Anon. Water and Water Engineering, **31**: 365, 212, May 20, 1929. This plant, claimed to be first of its kind in the world, operates electrically, is fully automatic, and represents a new principle in engineering. The crank shaft common to reciprocating engines has been eliminated and the reciprocating movement of the piston changed, rotary mo-

tion being delivered at the desired speed without external gearing. Float switches control the pumps.—*Arthur P. Miller.*

**Wenalt Reservoir, Cardiff. Special Construction Works.** G. W. Cover. Water and Water Engineering, 31: 365, 213-219, May 20, 1929. A rather technical discussion of the geology of location on which this new reservoir is situated, of certain subsidences which took place during construction, and of the exploration work done. Writer also discusses cementation of the boreholes with the idea of sealing fissures near the surface, removal of some superficial deposits, and reasons for modifying the reservoir design.—*Arthur P. Miller.*

**Shanghai Waterworks.** Anon. Water and Water Engineering, 31: 365, 229-230, May 20, 1929. A gain of 12 percent in population of Shanghai since 1921 makes the consumption total something over 13 million gallons. The increasing demand has caused the owning company to add steadily to its purification and pumping plants and to its distribution system. Demand for water fluctuates greatly. The heavy peak load is usually reached in forenoon and is exceptionally pronounced on a fine day following s series of wet ones. The source of supply is the very turbid and unclean Wangpoo River. On a bad day bacteria reach 20,000,000 in a tumblerful. The purification works remove on average 99.99 per cent of the bacteria. The article also touches upon the engines, boilers, and machinery in pumping plant.—*Arthur P. Miller.*

**Iodometric Determination of Small Quantities of Copper.** C. Dahl. Tids. Kemi Bergvesen, 7: 8-10, 1927. From Chem. Abst., 22: 2526, July 20, 1928. Accuracy of titration was studied in determining amounts of about a few tenths milligram of copper. Titrations were carried out in volume of 10 cc. with 0.02 N thiosulfate from 1-cc. buret graduated in hundredths of a cubic centimeter. Suitable amount of potassium iodide was found to be 0.2 gram. Addition of hydrochloric or sulfuric acid caused too high results. Accurate determination of amounts from 0.1 to 0.2 mgm. copper were obtained with addition of 0.24 to 5.0 cc. pure acetic acid, that is, even up to 50 per cent acetic acid in titration liquid. Maximum error was 0.009 mgm., results being 0.001 to 0.009 mgm. higher than exact values. All titrations in acetic acid solution were finished in one to three minutes and limit was very sharp. If volume is increased, or if less potassium iodide is used, titration time is increased and limit is less sharp. Titrations in neutral solution gave same results as in acetic acid solution. Presence of reasonable amounts of ammonium nitrate does not interfere with accuracy, but titration time is somewhat increased. Considerable amounts of ammonium acetate will make reaction incomplete.—*E. E. Thompson.*

**Test Results for Centrifugally Cast Iron Pipe.** H. Koester. Gas u. Wasserfach, 71: 391-3, 1928. From Chem. Abst., 22: 2535, July 20, 1928. Tests of ordinary and centrifugally cast iron pipe show that latter are much stronger. —*R. E. Thompson.*

**Annealing of Copper.** N. R. STANSEL. Gen. Elec. Rev., **30:** 276–80, 1927; Sci. Abstracts, B., **30:** 405. From Chem. Abst., **22:** 2544, July 20, 1928. Annealing at proper temperature will restore original properties to metal whose grain shape and properties have been altered by cold work. Essential conditions for copper annealing are: temperature limits of 315–400°, uniform distribution of heat flux, and neutral atmosphere in furnace.—*R. E. Thompson.*

**Corrosion of Copper and Brass in Reference to the Condenser-Tubing Problem.** V. DUFFEK. Korrosion u. Metallschutz, **4:** 56–8, 1928. From Chem. Abst., **22:** 2541, July 20, 1928. Distilled and natural waters, in presence of air, cause formation of initial protective layer of oxides on copper. Layer then becomes darker and porous, permitting attack beneath. In presence of air, copper is readily attacked even by very dilute acids, and also by aqueous solution of sodium or potassium hydroxide. In partially immersed specimens, corrosion occurs rapidly at air-liquid boundary; localized aëration causes pitting. Brasses behave in same manner as copper. Additions of 0.01 to 0.02 per cent arsenic to alloy prevent localized attack. Brasses are subject to localized corrosion by stray currents.—*R. E. Thompson.*

**A Small Filter for Water Softening.** E. QUITMANN. Gesundh. Ing., **51:** 340–2, 1928. From Chem. Abst., **22:** 2629, July 20, 1928. Zeolite filtration is probably simplest process for small plants. Small zeolite softener, using material known as "Natrolith" as softening agent, is described. Water produced has zero hardness, whereas soda-lime process yields water with hardness of 2 to 3°. "Natrolith" will remove iron, manganese, lead and ammonium compounds to certain extent, also many colored substances.—*R. E. Thompson.*

**Iodine Content of Some Water Supplies in Goitrous Regions.** G. H. BECKWITH. Proc. Soc. Exptl. Biol. Med., **25:** 117, 1927. From Chem. Abst., **22:** 2629, July 20, 1928. Determinations of iodine in drinking water of several towns and cities in Illinois and in several other goitrous regions showed very low content of iodine.—*R. E. Thompson.*

**Wells and Springs of Somerset.** L. RICHARDSON and W. WHITAKER. Dept. Sci. Ind. Research, Mem. Geol. Survey England, 1928, 270 pp. From Chem. Abst., **22:** 2628, July 20, 1928. Analyses and bibliography given.—*R. E. Thompson.*

**Water Sterilization by Chlorine.** F. DIÈNERT. Tech. sanit. munic., **23:** 50–8, 1928. From Chem. Abst., **22:** 2629, July 20, 1928. Lethal dosage of chlorine for cholera bacillus in water was 0.2 p.p.m. Dysentery bacillus required approximately twice dosage necessary to destroy *B. coli*. Flexner dysentery bacillus required dosage of 0.18 p.p.m.; Shiga bacillus 0.15 and *B. paratyphosum* 0.2 p.p.m. Similar results were obtained with both liquid chlorine and sodium hypochlorite in water treatment. Chlorine in chlorine peroxide was fully as efficient as chlorine in sodium hypochlorite or as liquid-chlorine. Theories of microbial destruction by chlorine are discussed. Chlorine treatment of water must be varied according to amount of organic matter present, nature of bacteria, and clearness of the water.—*R. E. Thompson.*

**Determination of Oxygen in Water.** F. Liebert and W. M. Deerns. Chem. Weekblad, 25: 226-8, 1928. From Chem. Abst., 22: 2630, July 20, 1928. Accuracy of several methods (Winkler, Romijn, Smit) for determination of oxygen in water was studied. Winkler method gave satisfactory results, accurate to 0.008 cc. per liter, when organic matter was not too high. Results tabulated.—*R. E. Thompson.*

**Pollution Problems in the State of Washington and Their Solution.** H. W. Nightingale. Trans. Am. Fish. Soc., 57: 294-300, 1927. From Chem. Abst., 22: 2630, July 20, 1928. Domestic sewage free from trade wastes is not harmful to fish life unless it reduces oxygen content to less than 30 percent saturation. Sulfite wastes from pulp mills are very destructive, since wastes from 50-ton sulfite mill equal sewage from city of 81,000. No special toxic action with sulfite wastes has been found. Wastes from mill using lime soda process have proved very destructive to young fry. Black ash wastes are very destructive to seed clams. Discussion of legal control of industrial wastes is included.—*R. E. Thompson.*

**Toxicity Experiments with Fish in Reference to Trade Waste Pollution.** D. L. Belding. Trans. Am. Fish. Soc., 57: 100-19, 1927. From Chem. Abst., 22: 2630, July 20, 1928. Factors that must be considered in studying effect of water pollution on fish outlined and effects of various chemicals on fish life described. Copper sulfate shows wide variations in toxicity.—*R. E. Thompson.*

**The Law Relating to the Pollution of Rivers (England).** Alfred Bebbington. Munic. Eng. Sanit. Record, 79: 436-7, 1927. From Chem. Abst., 22: 2630, July 20, 1928. Comment on Rivers Pollution Prevention Act, 1876, West Ridings of Yorkshire Rivers Act, 1894, and Salmon and Freshwater Fisheries Act, 1923.—*R. E. Thompson.*

**Treatment of Feed Water.** W. G. Carey. Fuel Econ. Rev., 6: 36-9, 1927. From Chem. Abst., 22: 2630, July 20, 1928. Review.—*R. E. Thompson.*

**Heat Transfer in Heating Tubes.** Werner Eikmann. Arch. Wärmewirt, 9: 5-8, 1928. From Chem. Abst., 22: 2652, July 20, 1928. Tests were made on two-pass waste heat boiler, heat transfer formula being developed: $k = 98 \times 10^{-10} d^{4.04} + 88 w/d$, where $k$ is heat transfer in kilogram calories per square meter per hour per degree, and $d$ the temperature difference between gas and water.—*R. E. Thompson.*

**Purifying Tannery Wastes.** J. T. Travers. U. S. 1,672,586, June 5. From Chem. Abst., 22: 2682, July 20, 1928. Reaction is effected between acid and alkaline wastes and waste is freed from suspensoids precipitated as result of such reaction: after removal of these suspensoids, waste is treated with reagent such as ferrous sulfate, or alum, capable of precipitating colloidal and finely suspended materials and liberating nascent oxygen and latter is permitted to affect further purification and precipitated colloids are coagulated.—*R. E. Thompson.*

**Hetch Hetchy Water Project.** Eng. News-Rec., 102: 238, February 7, 1929. Approval in 1928 of bond issues totaling $65,000,000 provided sufficient funds for finishing 168-mile aqueduct, as well as for purchasing distribution system of Spring Valley Water Co. There remain to be constructed 29 miles of tunnel through Coast Range and 45 miles of steel pipe line across San Joaquin Valley to connect Coast Range and Foothill tunnels. It is expected to deliver Hetch Hetchy water into San Francisco in 1932.—*R. E. Thompson.*

**Mokelumne Water Supply.** Eng. News-Rec., 102: 238, February 7, 1929. Rapid progress was made by East Bay Municipal Utility District on Mokelumne project during 1928. At Pardee dam, which provides main storage for new source of supply, concrete was 70 per cent completed on January 1, 1929. Expected that this 600,000-cubic yard structure will be finished one year in advance of contract time. Excavation of 2.2-mile outlet tunnel from reservoir has been completed and concrete lining is well started. The 95-mile aqueduct consisting chiefly of 65-inch longitudinally welded steel pipe has been finished. —*R. E. Thompson.*

**San Gabriel Dam.** Eng. News-Rec., 102: 238, February 7, 1929. Contract has been awarded and preliminary work is under way on record-breaking San Gabriel dam for Los Angeles County Flood Control District. Located on San Gabriel River, this structure, of arched gravity type, 430 feet above streambed and almost 500 feet above deepest rock excavation, will have capacity of 240,000 acre-feet to be used for flood protection and water conservation. Flood protection is to be assured by reserving about 85,000 acre-feet for this purpose. Dam will contain almost 4,000,000 cubic yards of concrete. Contract calls for completion in 6 years.—*R. E. Thompson.*

**Diablo Dam for Seattle Power.** Eng. News-Rec., 102: 238, February 7, 1929. Diablo dam, for city of Seattle hydro-electric development on Skagit River, was about 25 per cent completed on January 1. Nearly 400 feet high, this constant angle arch dam will contain 300,000 cubic yards of concrete and store 90,000 acre-feet for immediate use in the present Gorge plant. Proposed second plant at dam site will later also utilize storage provided. Completion expected in about one year.—*R. E. Thompson.*

**Coolidge Multiple-Dome Dam.** Eng. News-Rec., 102: 239, February 7, 1929. Closure of Coolidge multiple-dome dam on Gila River in Arizona was effected on November 15, and storage was begun about nine months ahead of schedule. Reported that no cracks or other defects have developed. Structure will store 1,200,000 acre-feet of water to be used for irrigating land adjoining Salt River irrigation project.—*R. E. Thompson.*

**Saint Louis Water Works Extension.** Eng. News-Rec., 102: 239, February 7, 1929. New water plant on Missouri River has been nearly completed. It is hoped to have entire plant in operation in March. Completed portions include intake and 87,000 feet of 60-inch riveted steel pipe leading to 100-million gallon Stacy Park covered reservoir. Filtration plant and accessories are well

advanced, together with the pumping and boiler plants. The turbine centrifugal pumps are installed and in readiness for operation. These include 100-million gallon per day and two 50-million gallon per day low-service pumps, and two 60-million gallon per day high service pumps.—*R. E. Thompson.*

**Sanitary District of Chicago.** Eng. News-Rec., 102: 240, February 7, 1929. Progress on sewage treatment plants of Chicago Sanitary District are outlined. Since granting of permit by Secretary of War on March 3, 1925, for diversion of water from Lake Michigan, construction work to value of $47,500,000 has been carried out. Value of construction work to date on sewage treatment program has been $78,500,000.—*R. E. Thompson.*

**United States Reclamation Dams.** Eng. News-Rec., 102: 238, February 7, 1929. Brief data given regarding status of dams under construction by Bureau of Reclamation.—*R. E. Thompson.*

**Detroit River Tunnels.** Eng. News-Rec., 102: 239, February 7, 1929. Twin vehicular tunnels under Detroit River, between Detroit, Mich., and Windsor, Ont., are under construction. River portion is to be of steel and concrete, in ten 248-foot sections, partly built up on land, floated to site and sunk in trench on river bottom. One section has been launched and 2 are under construction. Outside diameter is to be 30 feet. Portion of tunnels flanking river sections are to be shield-driven.—*R. E. Thompson.*

**New York Water Supply Extensions.** Eng. News-Rec., 102: 241, February 7, 1929. Four contracts were let by Board of Water Supply late in October for new pressure tunnel, 17 feet in diameter and 20 miles long, to supplement the one already in use for delivering water from Catskill aqueduct system. Plan for obtaining water from floodwaters of 5 New York tributaries of Delaware River and from Rondout Creek was approved in January but no appropriation was made available pending receipt of opinions on legality of plan. Proposal to develop 150 million gallons per day from wells on Long Island was removed from calendar of the Board at close of year.—*R. E. Thompson.*

**Saluda Dam.** Eng. News-Rec., 102: 240, February 7, 1929. Hydraulic sluicing has been started on the great earth-fill dam on Saluda River, 10 miles west of Columbia, S. C., being built by Lexington Power Co. When finished, dam will contain more than 11,000,000 cubic yards of fill and will create reservoir of 100 billion cubic foot capacity. Maximum toe to toe width will be 1150 feet and crest length will be nearly 8,000 feet. Project is expected to be finished about September 1, 1930, and will cost approximately $22,000,000.—*R. E. Thompson.*

**Boston Metropolitan Water Project.** Eng. News-Rec., 102: 241, February 7, 1929. Contract was let on April 30 for completion of 13½-mile tunnel from existing Wachusett reservoir on Nashua River in West Boylston to Ware River in town of Barre, to provide additional water supply for Boston Metropolitan District. Total of about 4 miles of tunnel has been driven. War

Department acted upon request to divert water from Ware River through this tunnel and application is now pending on request to divert water from Swift River, which will involve extension of tunnel for about 11 miles. Diversions are opposed by State of Connecticut as injuriously affecting its rights in Connecticut River. Tunnel under construction will divert floodwaters from Ware River above a diversion dam. Storage reservoir will be required on Swift River.—*R. E. Thompson.*

**Dam Construction and Design.** THADDEUS MERRIMAN. Eng. News-Rec., 102: 213–6, February 7, 1929. General discussion of practice and trends in dam construction and design, with particular reference to the safety of these structures.—*R. E. Thompson.*

**Report on Boulder Dam.** Eng. News-Rec., 101: 887–9, December 13, 1928. Board of engineers and geologists appointed under resolution of Congress have examined both Boulder Canyon and Black Canyon sites suggested for contemplated dam in Boulder Canyon region of Colorado River and found them both feasible for construction of dam 550 feet high to impound 26,000,000 acre-feet of water, latter site being considered preferable. Dam proposed by Bureau of Reclamation is of gravity type, curved in plan, with allowable stresses as high as 40 tons per square foot. Board believes that dam should be designed for maximum calculated stresses not exceeding 30 tons per square foot. Construction of power house below dam and proposed All-American Canal to supply water to Imperial Valley also reported feasible. Board believes proposed dam will be adequate to so regulate flow of lower Colorado as to control ordinary floods. Annual silt deposition in reservoir is estimated at 137,000 acre-feet per year, at which rate complete silting of reservoir would require about 190 years. Under present conditions of irrigation, continuous output of 550,000 horsepower is considered possible. Cost of dam, power plant, and canal is estimated at $165,000,000 and construction period at seven years.—*R. E. Thompson.*

**Water Consumption in English and Scotch Cities 19 to 98 Gallons.** JOHN BOWMAN. Eng. News-Rec., 102: 145, January 24, 1929. Domestic water consumption in 17 English and 14 Scotch cities tabulated, former ranging from 19 to 39 and latter from 39 to 98 United States gallons per capita per day. Higher consumption in Scotland is attributed to different system of sanitation, water-carriage method being employed throughout country. Data included for increased water use following installation of various plumbing fixtures.—*R. E. Thompson.*

**Second Hydro-Electric Plant on Chippewa River.** Eng. News-Rec., 102: 106–8, January 17, 1929. Illustrated description of new 21,600-kilowatt Chippewa power plant and dam in Wisconsin, which is latest addition to system of Northern States Power Co., Minneapolis, Minn.—*R. E. Thompson.*

**Effect of Temperature on the Strength of Concrete.** C. C. WILEY. University of Illinois. Eng. News-Rec., 102: 179–81, 1929. The effect of tem-

perature on the strength of concrete was determined, employing 6 x 12 inch cylinders, the results being shown graphically. In one series specimens were stored at the following approximate temperatures: 5°, 35°, 70°, 100°, and 205°F. Conclusions: (1) At 100°, the same strength is obtained in approximately half the time required at 70°. (2) At 35°, somewhat more than twice the time is required to reach the same strength as at 70°. (3) At all ages between three and twenty-eight days, the difference in strength is practically 30 pounds per square inch per degree Fahrenheit. (4) Frozen concrete shows practically no gain in strength. (5) Curing in saturated steam vapor (203 to 208°) has a deleterious effect, a slight increase in strength during the first few days being followed by a decided retrogression. Cylinders broken while still frozen at age of seven days had strength greater than that obtained at 28 days with normal curing at 70°. A second series of cylinders was stored in a moist room at 70°, groups being removed and place in a refrigerator at 5° for four days at the ages of one, three, five, seven and ten days, then thawed and returned to the moist room. Conclusions: (1) Frozen concrete when thawed out, again begins to gain strength. (2) Both the rate and magnitude of the gain in strength depend on the age at which the concrete is frozen and are materially less for the early ages. (3) Concrete frozen before a certain age, which may be termed the critical age, suffers permanent damage. (4) The critical age is apparently that at which the cement paste has developed sufficient strength and adhesion to the aggregate that free water cannot collect around the rock particles and in freezing break the bond with the cement. (5) For the mix and materials used in the experiments, the critical age appears to be between seven and ten days. The critical age is probably greater for leaner mixes and with coarser aggregate. (6) The strength of concrete frozen at the age of one day is less than half of that of unfrozen concrete. That frozen at three to five days has an indicated permanent loss in strength of 15 to 20 per cent. The loss in strength at seven days is small, if any, and at ten days no ultimate loss occurs, but the rate of gain in strength is distinctly retarded. It is recommended that all concrete be protected from freezing for at least 1 week at a temperature of 70°F., or twice as long at 35°.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

**Progress on Hetch Hetchy Water Supply Tunnels.** Eng. News-Rec., 102: 171, January 31, 1929. A 4-mile section of the 16.7-mile Foothill division of Hetch Hetchy aqueduct was holed through on December 6. Center lines of 2 headings as checked up on holing through were found to be 0.45 foot apart. Grades checked to 0.04 foot. Considerable water was encountered under pressures as high as 350–400 pounds per square inch, as much as 500 gallons per minute coming into heading at times through a single drill hole. Construction has been begun on 28.6-mile length of tunnel in Coast Range division. In addition to east and west portals, 2 portals will be opened in Alameda Creek and 10 other headings will be driven from 5 shafts ranging in depth from 254 to 760 feet.—*R. E. Thompson.*

**Electrical Subsoil Exploration and the Civil Engineer.** Irving B. Crosby and Sherwin F. Kelly. Eng. News-Rec., 102: 270–3, 1929. The electrical exploration method of determining subsoil conditions is outlined and its ap-

plication to such problems as the determination of bedrock position at dam sites is discussed. The method is based upon the fact that the various materials constituting the earth's crust offer different degrees of resistance to the passage of electric current. The electrical field created by the passage of a direct current between 2 earth contacts at the surface of the ground is regular in character if the ground is homogeneous, whereas if there is a mass present which is more resistant or more conductive than the adjacent material the field is distorted. When there are a number of strata of varying characteristics only an approximate solution can be reached, but when the beds are horizontally homogeneous and well differentiated vertically the problem can be solved with fair accuracy. The method was applied to the study of 2 dam sites on the Connecticut River near Littleton, N. H., in connection with the Fifteen Mile Falls development of the New England Power Association. The results obtained are described. Electrical prospecting will not eliminate drilling, but it will greatly reduce the cost by concentrating such drilling on checking the crucial conclusions of the electrical survey.—*R. E. Thompson* (*Courtesy Chem. Abst.*)

**High-Speed Construction Methods at Pardee Dam.** C. E. GRUNSKY, Jr. Eng. News-Rec., **102**: 258–62, February 14, 1929. Illustrated description of construction of Pardee dam, which is to store water on Mokelumne River for East Bay Municipal Utility District in California. Dam is of curved gravity type, will be 357 feet high and will create reservoir of 240,000-acre-foot capacity to store runoff from 575-square mile watershed. Annual runoff at dam site is estimated at 900,000 acre-feet. Total volume of concrete in dam will be 615,000 cubic yards, all of which is to be in place, according to contract, by January 5, 1931. On January 1, 1929, contractor was about 350 days ahead of schedule, more than 70 per cent concrete having been placed by February 1.—*R. E. Thompson.*

**Geophysical Foundation Study by Explosion-Wave Method.** A. T. PARSONS. Eng. News-Rec., **102**: 273–5, 1929. The explosion-wave method of investigating underground conditions, developed in mining and oil field work, is described and its possible application to such problems as the study of dam sites is discussed. A sensitive receiving device, termed a receptor, is placed a few feet below the surface of the ground and connected with an instrument which photographically records the time required by the energy sent out by an explosion to travel from the point of the explosion to the receptor. From the records so obtained the depth of level interfaces can be calculated accurately by means of a formula, which is given. For inclined or irregular interfaces various corrections have been devised, and formulas have been developed for determining successive depths to 2 or more interfaces. Essentially close agreements have been obtained with the results of actual drilling. It is believed that foundation surveys could be made by geophysical methods at a substantially lower cost than by core drilling.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

**Wire Points Keep Birds Off Water Supply Standpipe.** Eng. News-Rec., **102**: 77, January 10, 1929. Brief illustrated description of bird fence placed

around top of standpipe, 61 feet high and 64 feet in diameter, recently constructed for city water system of Tacoma, Washington. Fence consists of 3-inch lengths of 12-gauge wire sharpened at upper end and welded to a 2- x ½-inch plate which is bolted around top of standpipe. By placing wires only 1½ inch apart, rim is made unattractive to birds of sizes to be found at this height above ground level.—*R. E. Thompson.*

**Building a Safe Gin Pole.** C. W. HINES. Eng. News-Rec., 102: 194, January 31, 1929. Brief description of standard gin pole employed by Chicago Bridge and Iron Works in erecting elevated tanks.—*R. E. Thompson.*

**Reconstruction of Lafayette Dam Advised.** Eng. News-Rec., 102: 190–2, January 31, 1929. Data given from report of consulting board appointed to submit recommendations concerning present and future operations at Lafayette dam of East Bay Municipal Utility District, a rolled earth-fill structure which partially failed by subsidence when completed to within 20 feet of projected height of 140 feet. Although containing larger proportion of clay than desirable, dam would have shown no weakness if it had rested upon a firm foundation. Its slopes were conservative, materials were selected and distributed with unusual care, and workmanship was excellent. Failure was due to exceptional foundation conditions, notably the uncommon thickness of clayey alluvium and general plasticity of the material. This condition was determined only after painstaking examination subsequent to failure and could not have been anticipated except in light of exceptional experience. Reconstruction is recommended to height of 100 feet, with slopes of 5 to 1 and 7 to 1 on upstream and downstream faces respectively. This will provide base twice as long with respect to height as the original structure. Maximum water depth will be reduced from 116 to 76 feet and capacity from 10,590 to 3,700-acre-feet. Cost will be approximately $300,000.—*R. E. Thompson.*

**Spillway Cut Rushed to Safeguard Lake Pleasant Dam.** Eng. News-Rec., 102: 275–8, February 14, 1929. Flood in Agua Fria of size that might occur at this season of year could fill Lake Pleasant reservoir of the Maricopa County Water Conservation District in less than two days. Dam has been declared unsafe for load imposed by full reservoir, and, since capacity of the three 48-inch outlets through structure would afford but negligible relief, a serious situation has arisen. Committee appointed by State Water Commissioner recommend that cut in present spillway be made, 24 feet deep and 175 feet wide at bottom. This work is being carried out as rapidly as possible. Data from other reports on condition of dam and recommendations for repair of the cracks which render structure unsafe are included.—*R. E. Thompson.*

**Building a Concrete Reservoir for Portsmouth, Ohio.** R. J. TURRELL. Eng. News-Rec., 102: 97–9, January 17, 1929. Illustrated description of construction of 22-million gallon covered reservoir now in progress at Portsmouth. Reservoir is U-shaped in plan to conform to contour of ground, each leg being on hillside, so that inner side is a paved slope while outer side is 30-foot reinforced concrete retaining wall. Interesting features of construction are use of

traveling concreting tower and traveling gantry which straddles concrete wall and handles forms, which are made up in large units. Reservoir is at elevation of about 150 feet above level of business section and will maintain minimum pressure of 75 pounds per square inch in mains and provide storage of about three days' supply. In addition, a 400,000-gallon steel tower is being erected on hill above reservoir to give ample pressure to hilltop sections of city. Concrete is being proportioned by water-cement ratio method, wall concrete having strength of 2500 pounds and slump of 4 inches, and roof concrete, 2000 pounds and 6-inch slump. Floor is 3¾ inches of gunite, 1:3 mix, reinforced with 4 x 4 inch welded wire mesh, applied in 3 coats. Population has increased from 40,000 in 1921 to 60,000 in 1928.—*R. E. Thompson.*

**Automatic Siphon Control for Small Water Supply System.** Eng. News-Rec., 102: 76, January 10, 1929. Water supply of Meadow Lakes, a country club in Sierra Nevada Mountains, is obtained from wells on crest of ridge near upper boundary of property which are siphon-connected to distribution system. Collection of gases at bend of siphon necessitated frequent priming of system. Device installed to correct this difficulty is described which consists of tilting platform upon which are mounted 2 tanks, each of which is connected alternately to siphon, the discharge of the water creating vacuum which removes air from siphon.—*R. E. Thompson.*

**Power Projects Recommended for Vermont Flood Control.** Eng. News-Rec., 102: 72–3, January 10, 1929. Data from report of advisory committee appointed by Governor Weeks given. Construction of power reservoirs on 5 major rivers recommended.—*R. E. Thompson.*

**Raising of Aswan Dam in Egypt Proposed.** Eng. News-Rec., 102: 278–80, February 14, 1929. Details given from report of international commission to Egyptian Government, which recommends increasing height of Aswan dam of Nile River 30 feet. Dam, which is of masonry, was constructed in 1898–1902 and was raised 16.4 feet in 1907. Greatest height of original structure above foundations was about 96 feet and maximum depth of water in reservoir was 66 feet. Asphalt key is provided in plane of junction of old and new work to prevent leakage.—*R. E. Thompson.*

**Changes in Flow Over Niagara Falls in Prospect.** Eng. News-Rec., 102: 281–3, February 14, 1929. Details given of a convention between United States and Great Britain, signed on January 2 and now awaiting ratification by the Canadian and United States legislatures, providing for remedial works on Niagara River above Falls to distribute water so as to ensure at all seasons an unbroken crest line at falls, and temporary and experimental diversion of water from river for power purposes in addition to amounts specified in treaty of 1909. Estimated cost is $1,750,000.—*R. E. Thompson.*

**Progress of Tests and Design of Bonnet Carré Spillway.** Eng. News-Rec., 102: 284, February 14, 1929. Progress outlined of tests being conducted in connection with design of spillway above New Orleans to skim 250,000 second-

feet of flood crest of Mississippi River and discharge it by floodway into Lake Pontchartrain. Project is one of auxiliaries in New Orleans flood control program.—*R. E. Thompson.*

**Boiler Plates.** ANTON POMP. Stahl u. Eisen, 48: 681–9, 1928. From Chem. Abst. 22: 2730, August 10, 1928. The harder plates, especially nickel-steel plates, are better than low-carbon plates at higher temperatures in their mechanical characteristics, resistance to fatigue, and tendency to crystallize. —*R. E. Thompson.*

**Aggregate Moisture Determination by Specific Gravity.** W. M. DUNAGAN. Eng. News-Rec., 102: 285, 1929. Further discussion in reply to criticism of McCALL (cf. E. N. R. 101: 966). D. states that determination of both free moisture and absorption by the specific gravity principle has been thoroughly checked with the flame method and found to give results usually within 0.1 per cent. This is well within the accuracy of the relations establishing the water-cement ratio curves.—*R. E. Thompson (Courtesy Chem. Abst.).*

**The Value of Lead Paints for Purposes of Protection of Iron.** A. EIBNER and W. LAUFENBERG. Korrosion u. Metallschutz, 4: 107–10, 1928. From Chem. Abst., 22: 2731, August 10, 1928. Imperviousness of linseed oil films to water increases with increasing linseed oil-lead compound content. Compounds formed are lead soaps and lead glycerol combinations. From study of films it was concluded that physical state as well as chemical nature of pigment influences stability of protective film.—*R. E. Thompson.*

**The Problem of Metal Corrosion.** J. HAUSEN. Korrosion 3: 17–8, 1928. From Chem. Abst., 22: 2732. Concluded that results of laboratory experiments on corrosion of brass are not very reliable and that decisions must be based upon practical trials.—*R. E. Thompson.*

**Water Purification.** ALEXANDER HOUSTON. Chemistry and Industry, 47: 22–5, 1928. From Chem. Abst., 22: 2802, August 10, 1928. Includes illustrations of new Walton works.—*R. E. Thompson.*

**The Chemistry of Mineral Water.** J. KNETT. Oesterr. Chem. Ztg., 31: 77–9, 1928. From Chem. Abst., 22, 2802, August 10, 1928. Mineral water discussed from standpoint of composition and of methods of reporting analyses.—*R. E. Thompson.*

**Filter Regulators.** J. J. ROELANTS, Jr. Water and Gas, July 27, 1928, 143–4. Accurate regulation of rate of filtration can be effected by use in regulating chamber of overflow movable vertically, upper edge of which is automatically kept at fixed distance beneath surface of water in chamber by floats. Heights of water above overflow correspond to definite rates of filtration. Level of water above filter and resistance of filter should remain constant. Latter condition is hardly attainable. By floats, level in regulator chamber may be kept at constant level lower than normal level of water above filter to an

amount corresponding to maximum allowable resistance of filter. Quantity of water overflowing in liters per second, $Q, = Bh\ a\ \sqrt{2gh} = (B\ a\ \sqrt{2g})\ h^{\frac{3}{2}}$, in which $B$ is length of overflow in decimeters, $h$ the height of overflowing water above overflow and $a$ a coefficient dependent upon form of overflow. If $a$ is taken as constant for heights of overflow not widely differing, then $Q$ is proportional to $h^{\frac{3}{2}}$.—*R. E. Thompson.*

**Notes on Recent Developments in Fuel Technology.** R. Wigginton. Fuel in Science and Practice, 7: 193–4, 241–4, 1928, cf. C. A., 22: 2254. From Chem. Abst., 22: 2825, August 10, 1928. Brief review of, among other subjects, oxygen removal from feed water and softening with barium salts.—*R. E. Thompson.*

**Coal-Tar Paints as Metal Preservatives.** A. V. Sivolobov and A. I. Iuzhilin. J. Chem. Ind. (Moscow), 3: 1308–10, 1926. From Chem. Absts., 22: 2848, August 10, 1928. Coal-tar paints, which usually contain fillers such as portland cement, lime, etc., and a thinner such as kerosene or light fractions of coal-tar distillates, are not harmful to iron and preserve it from rusting as long as coating of paint remains intact. For painting iron roofs, however, these paints can replace oil paints only on condition of repainting every year, since they are very apt to soften in summertime and weather off. Account included of various experiments on speed of drying of these paints and their anti-corrosion effect.—*R. E. Thompson.*

**The History of the Chlorination of Drinking Water.** Spitta. Reichs-Gesundheitsblatt., 1928, 3: 533. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 1, A-5, November, 1928. An account of the development and present state of the practice of drinking water chlorination in Germany. The first attempt to sterilize water by chemical means was made in 1893, by Ohlmuller, who made experiments in the action of ozone on bacteria. This method gained little popularity and although investigations were carried out later on the use of chlorine, this method also fell into disrepute, and was really reintroduced in 1910 from America where its use in the purification of polluted surface waters had adequately demonstrated its effectiveness. Since the war the use of chlorine has become increasingly popular in Germany, but in general purely as a supplementary process to other methods of purification. Chlorine is also used in water investigations to determine the chlorine demand, a determination which amplifies the permanganate oxygen absorption test.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**The Determination of the B. Coli Count in Water.** A. Massink. Rep. of Rijksbureau voor Drinkwater voorziening, The Hague, Holland, 1927, page 100. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 1, A-6, November, 1928. Review of methods of determining *B. coli* in water and of the improvements in technique which have been introduced in recent times. Particular reference is made to American practice on which the method used at the Rijksbureau is largely based.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**Filtration of Alkaline Waters.** J. Gordon and R. E. Hall, E. P. 291, 970. Brit. Chem. Abst., 1928, (B), 626. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 1, A-8, November, 1928. The use of various silicates (e.g., of iron, magnesium or calcium) in preference to sand for filters dealing with hot boiler waters, which are alkaline owing to the pretreatment they have received for softening purposes, is recommended because of their lower solubility under such circumstances. For the filter bed a granulated smelter slag obtained from copper smelting may be used. As the silicates suggested have a fairly high specific gravity the time taken to wash the filter by reversal of flow is not excessive.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**The Action of Carbon Dioxide on Water Organisms.** J. Nikitinsky. Contr. f. Bakt., 1928, 73: 481. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, Vol. 12, October, 1928. Experiments are described on the effect of water saturated with carbon dioxide at 15°C. on a group of water organisms including cyclops, daphnia, several larvae and rotifera. These organisms were killed in this water in a comparatively short time (varying from ten seconds to ten minutes). That this effect is due to carbon dioxide and not to lack of oxygen was shown by the fact that all the organisms existed for a considerably longer time in an atmosphere of hydrogen. Further experiments showed that the action of carbon dioxide is not due to impurities in the gas or to its acidity. Compared with other chemicals, copper sulphate, mercuric chloride, etc., it is extremely toxic. It appears however that saprobic organisms and many water plants are much more resistant to the gas than those mentioned above.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**The Removal of Phenol from Coke Oven Wastes.** F. Raschig. Z. f. angew Chem., 1927, 40: 897. Gas World, 1928, October 6. Coking Section page 18; Gas. u. Wasserfach 1928, 71,860. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 1, C-3, November, 1928. The method developed by the Emschergenossenschaft for the biological purification of coke oven wastes has proved to be too expensive in practice and has largely been superseded by the benzol extraction method. In this process the gas liquor, before removal of ammonia, is washed in a tower, containing Raschig rings, by a counter current of benzol or toluol. It is better to prewarm both benzol and ammonia liquor. The extraction of the phenol from the benzol was found difficult, as neither shaking with soda nor distillation is completely effective. Satisfactory results are however being obtained using a distilling column 50 feet high filled with Raschig rings.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**The Sensitivity of Fish to Phenol.** W. Speyer. Z. f. Fischerei, 1927, 25: 503. Wasser u. Abwasser, 1928, 24: 256. Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 12, October, 1928. In the fruit growing district in Hanover, fruit trees have been sprayed with a carbolic acid preparation as a protection against

the apple leaf flea (Psylla mali Schm). Running through the district are a number of ditches which contain a large amount of aquatic life, including fish. During the spraying of the trees some liquid has reached the ditches and the concentration of phenol produced is estimated at 0.8 parts of phenol in 100,000 parts of water. Such a concentration, according to Holzingers, is toxic to fish. It is therefore recommended that care be exercised in the use of such material in the neighborhood of waters, which are valuable from a fishery point of view.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**A Contribution to the Study of the Purification of the Waste Waters from Sugar Factories.** E. Modrow. Zentr. f. d. Zuckerindustrie, 1926, **34**: 556. Wasser u. Abwasser, 1928, **24**: 57. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 9, July, 1928. The separation of the fermentable substances dissolved in the effluent, which cause the growth of fungus in streams, can be effected by land filtration or by chemical means. A partial clarification can be obtained, for example, by treatment with lime, but this is insufficient, especially when the effluent is discharged into a small stream. The author describes a plant for the treatment of the waste waters by fermentation.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**The "Mammut" Thickener.** Steen. Deuts. Zuckerind., 1927, **52**: 275. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 9, July, 1928. The apparatus described is a tank for the continuous separation of sludge from beet transport and washing waters. The tank is circular, and has a W shaped diametrical cross section, which gives a large surface area for a given volume of tank. The water to be clarified enters the apparatus centrally and flows radially outwards towards the periphery of the tank where it runs into an annular trough and is discharged. The sludge which falls onto the sloping sides of the tank arrives at the bottom in a well mixed condition and is easily pumped.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**New Plant for the Removal of Oil at the Factory of C. F. Bochringer Und Sohne G. M. B. H. Mannheim—Waldhof.** Schmeitzner. Chem. Ztg., 1928, **52**: 388). Chem. Zentr., 1928, **99**: 3104. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 11, September, 1928. A description of a plant installed by the Deutsche Abwasser-Reinigungs-G. m. b. H. for the separation of oil from oily waters.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**Catchment Area Boards for the Control of Rivers.** W. Lionel Jenkins. Surveyor, **75**: 1928, 5, January 4, 1929. A general discussion of conditions in Great Britain relative to the administration of the stream pollution prevention acts, and of the advantages of creating catchment area boards for this purpose. —*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

**Industrial Effluents and Their Purification.** A. PRITZKOW. Reprint from "Chemische Technologie der organischen Verbindungen" edited by R. O. Herzog. C. Winters Universitatsbuchhandlung Heidelberg, 1927. Wasser u. Abwasser, 1928, 24: 58. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 9, July, 1928. After referring to the importance of the effluent question in industry, the author discussed the polluting effects of industrial waste waters and gives the regulations controlling their discharge in several German states (Prussia, Bavaria, Saxony, Wurtemberg, Baden, Thuringen) and in the Empire.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

**The Question of the Pollution of Lake Constance by the River Schussen and the Possibility of its Estimation by Observations of Protozoa.** A. WETZEL. Intern. Rev. ges. Hydrobiol v. Hydrograph., 1928, 19: 217. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 9, July, 1928. The lower stretches of the area at the mouth of the river Schussen as well as a number of stored waters and neighbouring pools have been examined from a chemical and biological standpoint. The waters of the Schussen are at all depths well aërated with oxygen; decaying sludge and hydrogen sulphide are absent. The scanty detritus settling from the river is well broken up and only slightly putrescent. The waters are slightly alkaline in reaction. In the stored waters and pools the oxygen content in the upper layers is on the average somewhat lower; at the bottom there is an oxygen free layer of decaying sludge of moderate thickness which contains free hydrogen sulphide. These waters are in part in free communication with the river but no consequent deterioration of the Schussen was noticeable. The Protozoa of the river corresponded to those present in unpolluted pools. Sludge-decomposing forms were only found in isolated cases whilst in the decaying sludge of the stored waters and pools they occurred regularly. These facts lead to the conclusion that the Schussen was not polluted during the period under examination—Autumn, 1926, to Spring, 1927. A study of the fauna in conjunction with a chemical investigation has been shown to be a useful means of judging the quality of a water.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

**The Drinking Water Supply of Vrederust at Bergen Op Zoom.** J. E. CARRIERE. De Ingenieur, No. 18, 1928. Water and Water Engineering, 30: 357, 442, September 20, 1928. The supply at Vrederust was formerly drawn from comparatively shallow wells and was highly colored, aggressive, and could only be freed from iron with difficulty. A mixture of equal portions from new deep wells drawing from the Tertiary strata which is rather hard, gave a satisfactory effluent, not too hard, non-aggressive, and easily freed from iron by aeration or filtration through coke.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

**The Provision of Drinking Water in Holland now and in the Immediate Future.** W. F. J. M. KRUI. Paper before 33rd Congress for Public Health Regs. Rotterdam, July 6–7, 1928, 48 pp. Water and Water Engineering, 30: 357,

442, September 20, 1928. The progress of water works in Holland since the first installation in Amsterdam, 1853, is reviewed. Important factors in water supply are enumerated and available sources given. Desirability of the planning of small water works so they can be conveniently linked with larger regional schemes is brought out. Records are necessary for future developments.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

**Making Chlorine Treatment Dependable and Accurate.** H. S. Hutton. West Virginia University College of Engineering Bulletin, Prof. of the Fourth Annual Conference on Water Purification, 14: 3, 119, November, 1928. A plea for duplicate chlorinator installations or at least duplicates of the most essential parts when one machine is in use, in order to assure uninterrupted service. Frequent ortho-tolidine tests for residual chlorine are recommended as the most important check on efficient chlorinator operation.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

**Uncovered Meter Pit Renders City Liable.** Leo T. Parker. Water Works Eng., 82: 16, 1089, July 31, 1929. Digest of several legal decisions on water works questions: (1) City is held liable for damage for leaving an uncovered meter pit in a grass plot where pedestrians were not supposed to walk. (2) Verbal agreements do not alter written agreements. (3) Courts uphold perpetual easement on water lines and require buildings to provide easy access to watermains even if the subdivision has been replatted and the streets where the main originally was, changed.—*Lewis V. Carpenter*.

**What is the Pressure Loss in Service Between Main and House?** James E. Gibson. Water Works Eng., 82: 12, 815, June 19, 1929. A series of tests were made at Charleston, S. C., of the loss in head through the corporation cock, 25 feet of service pipe, curb cock, meter, ten feet of pipe from meter to property line, and the total loss of the composite service from main to property line. A series of tables gives percentage loss by increments for each fitting and pipe at intervals of 5 gallons flow, the velocity in feet per second through the pipe, the velocity head, and the entrance head. Detailed data are furnished on 1- and $\frac{3}{4}$-inch lead and copper pipe. The tabulations are very good.—*Lewis V. Carpenter*.

**Welding by Contract a Large Steel Pipe Pitted by Electrolysis.** William W. Brush. Water Works Eng., 82: 13, 813, June 19, 1929. A 66-inch riveted steel pipe made of $\frac{7}{16}$-inch plate and coated with bitumastic enamel paralleled an overhead trolley line which had poor bond between the rails. Leaks appeared and it was found that the difference in potential between rail and pipe was 7 volts. A steel plate was placed to bond the pipe to the track, but was not successful in stopping electrolysis. The trolley discontinued and the pipe line was repaired. In a length of 723 feet there were 40,000 to 50,000 pits of which 25,040 were welded. One crew could weld 300 to 400 holes per eight-hour day, using electric welding. Cost of job averaged $20.00 per foot.—*Lewis V. Carpenter*.

**Who is Liable for Water Line Damages?** Leo T. Parker. Water Works Eng., 82: 12,719, June 5, 1929. Where one of two persons not intending to do a wrong is caused damage, the one is responsible whose greater negligence caused the injury. *Spring Brook Water Co.* vs. *Pennsylvania Coal Co.* The water company laid lines along a highway which was built over coal owned by Pennsylvania Coal Co. When the coal was mined the water lines were badly damaged. Court held that water company was not entitled to damages. Ruling said that burying of a pipe line along a highway was an additional liability and if the water company did not have special permission to lay the line they could not collect damages. In *Josey* vs. *Beaumont Water Works*, the water works company was under a contract to furnish, at a specified monthly rental, water for fire protection through the customer's private pipe line. Contract did not stipulate that the company was to repair the pipe line. Without notice to the customer, the water company cut off the supply of water; whereupon the pipe became defective and leaked. A fire occurred destroying property and merchandise valued at over $77,000. Court ruled in favor of the water company, stating that the customer forfeited his rights to get water when his pipe line was out of repair. Court held in *Aschoff* vs. *City of Evansville* that any one who damages even a private pipe line is liable for damages caused by water. Another decision holds that city is not liable for fire department damage to pipes. The court held that the city is not liable for negligence of members of fire department acting within the scope of their duty.—*Lewis V. Carpenter.*

**Water Supply: What Courts Say About it.** Leo T. Parker. Water Works Eng., 82: 14,957, July 3, 1929. It has been well established in court that the consumer is bound to pay for all water delivered into his pipes, unless the loss results from negligence of the water company or of its employees. The article gives a number of court decisions on: Water Commissioner notes equivalent to municipal bonds; legal interpretations of authority of Public Service Commissions; award for condemned property must include all damages and value; City entitled to take lot for erection of standpipe; and water plant may earn profit on reasonably necessary investment.—*Lewis V. Carpenter.*

**When May Cities be Held Responsible for Illness from Impure Water?** Caleb Mills Saville. Water Works Eng., 82: 13, 819, June 19, 1929. Author cites a number of court decisions under which water companies, both municipal and privately owned, have been held responsible for furnishing impure water. It is a matter for the court to decide, where the accountability should be placed; the trend of decisions is to hold both the governing body and the individual official in direct charge of the works liable. In other words, liability for failure properly to safeguard a water supply cannot be sidestepped as a governmental function, nor can the crime of causing death or jeopardizing health be legalized.—*Lewis V. Carpenter.*

**Biochemical Oxygen Demand of Certain Substances.** G. E. Symons with A. M. Buswell. Ind. End. Chem. (Analytical Ed.) 1: 161, 1929. Study of the biochemical demand of lactose, starch, cellulose (filterpaper), sodium

palmitate, peptone, and urea were undertaken as a background for additional work. An interesting curve showing the demand for carbonaceous material with the characteristic two-stage oxidation for C and N substances is given.—*Edward S. Hopkins.*

**The New Water Treating Plant of the Santa Fe at Grand Canyon.** H. B. HOMMON. Amer. Ry. Engr. Assoc., 31: Bull. 317, 67–82, 1929. All water used at the Grand Canyon National Park resorts is handled in tank cars from Flagstaff or Puro, Ariz., 100 or 120 miles, at cost of $3.09 per 1,000 gallons, as pumping water from canyon against 6000 feet head is impractical. Activated sludge treatment with chlorination for sewage wastes and alum treatment of laundry water with subsequent rapid sand filtration for both since 1927 has resulted in reclamation of about 99 per cent of the water used in satisfactory condition for boiler, laundry, lawn sprinkling and similar purposes. Cost for reclaimed water averages $0.574 per 1,000 gallons, a saving of $2.50. Operation is handled jointly by Santa Fe RR. and U.S.P.H.S.—*R. C. Bardwell.*

**One Plant Replaces Three at Water Station.** C. V. BUCHER. Railway Engineering and Maintenance, 25: 10, 416–418, 1929. Trouble with muddy and corrosive water from Leading Creek and the Ohio River at the Hobson, Ohio, terminal of the New York Central RR., was overcome by installation of shallow drilled wells. Automatic electrically operated centrifugal pumps are used in 36-foot pits. A clear satisfactory water is obtained.—*R. C. Bardwell.*

**Melting Ice Deposits Concrete in Deep Well.** Anom. Railway Engineering and Maintenance, 25: 9, 387, 1929. The Chicago and Northwestern Ry. at their Proviso Yard, Chicago, Ill., used a unique method for plugging 16-inch well with concrete between the 2090- and 2225-foot levels, to block flow of objectionable salt water, by using block of ice to hold the concrete in 10 feet by 12 inch sand-bucket until it was spotted at desired location where the melting ice released the charge of concrete and accomplished desired results.—*R. C. Bardwell.*

**Protection of Catchment Areas.** JOHN F. SKINNER. Jour. New Eng. W. W. Assoc., 43: 1, 1–13, March, 1929. Recommends purchase of marginal strips around reservoirs and lakes used for water supply. The total catchment area of the municipal water supply of Rochester, N. Y. is 66.2 square miles, of which 48.0 square miles are tributary to Hemlock Lake, 12.4 square miles to Candice Lake, and 5.8 square miles to Candice outlet. In 1895 the city purchased a strip of land 200 feet wide from high water line around Hemlock Lake. Other purchases from time to time have brought the total up to 3,517 acres. From 1902–1928 about 1,500,000 trees were planted on 1,250 acres. A project for increasing the water supply by a large addition to present watershed calls for acquisition of land by the city which will total 30,000 to 40,000 acres. Due to difficulty of surveying this large expense of rough and wooded country, aërial surveying was resorted to and photographic map of scale of 800 feet to an inch prepared.—*H. H. Gerstein.*

**A New Kind of Pipe for Water Mains.** R. W. MITCHELL. Jour. New Eng. W. W. Assoc., **43**: 1, 18–27, March, 1929. The centrifugal process for casting concrete pipe is for the purpose of (1) overcoming the segregation of the aggregate (2) quickly and certainly removing the objectionable laitance from the inside of the pipe and (3) definitely controlling the diameter. The principles involved are simple. Rate of spinning is so controlled that, while sufficiently high to produce a moderate compacting effect, it is yet not high enough to cause segregation. The charge is uniformly distributed along the whole length of the pipe and the mix used is relatively dry, so as to minimize the amount of cement and laitence brought inside the pipe. The required density is produced mechanically by means of a combination knife and trowel that compacts the concrete and trims it to dimensions. Centrifugally cast concrete pipes can be made to withstand practically any pressure and remain structurally sound; but they will not remain water-tight, due to cracking of shell. Asphalt applied on inside of shell serves as a waterproofing which withstands effects of pressure. Describes method of applying smooth surfaced asphalt lining.—*H. H. Gerstein.*

**The New McTavish Pumping Station at Montreal, Quebec.** CHARLES J. DES BAILLETS. Jour. New Eng. W. W. Assoc., **43**: 1, 32–7, March, 1929. The City of Montreal was supplied with water both from its own system and from the privately owned system of the Montreal Water and Power Company. The City having acquired the latter is working on the problem of interconnecting the two systems and operating the whole under one management. The McTavish Station, by nature of its location, can conveniently add to the district now served by it that connected to the Outremont reservoir of the private company. An addition will be designed to increase its capacity to appoximately 30 million gallons daily. This will eliminate two pumping stations of the former private system.—*H. H. Gerstein.*

**Unusual Methods of Water Purification.** MARTIN E. FLENTJE. Jour. New England W. W. Assoc., **43**: 1, 38–43, March, 1929. Unusual methods of solution adopted for problems encountered in taking over supervision of purification of a number of water companies by a central holding corporation. Water fleas and Crustacea in water were found to be killed by a dose of 2.0 p.p.m. copper sulphate in twenty-four hours, or by a dose of 1.75 p.p.m. chlorine in twelve hours; while 3.5 p.p.m. chlorine killed in thirty minutes. At one plant the soda ash which was applied for prevention of corrosion was mixed in proper proportion with sodium thiosulphate for the purpose of dechlorination. Whiting, a chemical not commonly met with in water purification, was successfully used to provide alkalinity to react with alum without the objectionable peptizing of soda ash or lime upon the color present. Use of whiting increased filter runs from two to eight hours. Experiments are now being made to determine whether sludge from a lime soda treatment plant can be used in place of whiting.—*H. H. Gerstein.*

**The Oxy-Acetylene Process in Modern Industry with Practical Reference to Piping Field.** R. W. BOGGS. Jour. New England W. W. Assoc., **43**: 1, 44–9,

March, 1929. The successful use of the oxy-acetylene process for pipe welding depends on what the author terms "procedure control," a system whereby each step of the production process is developed, supervised, and controlled so as to secure the highest possible efficiency.—*H. H. Gerstein.*

**Average Rainfall Tables for Northern New England.** Gragg Richards. Jour. New England W. W. Assoc., 43: 1, 50–5, March, 1929. Tables of mean monthly and seasonal rainfall based on data from 1881 to 1925.—*H. H. Gerstein.*

**A Gas Producer Plant for Water Pumping at Manchester, Mass.** Raymond C. Allen. Jour. of New England W. W. Assoc., 43: 1, 56–9, March, 1929. Equipment of pumping station, consisting of duplicate units of Smith gas producers, Nash gas engines, and Gould vertical triplex pumps has been in continuous operation for the last twenty years. After this period gas engines are in good condition, but the cylinders have been re-bored so often that further efforts in that direction have become unsafe and general wear is such that further repairs unwarranted. Gas producers are in similar condition, with labor cost high. Pumps are in remarkably good condition. It was therefore decided to retain these and install electric drive.—*H. H. Gerstein.*

**Decolorization by Storage in Clean Bottomed Reservoirs.** Karl R. Kennison. Jour. New England W. W. Assoc., 43: 1, 60–75, March, 1929. Detailed data obtained from two clean-bottomed reservoirs show that there is approximately 20 per cent reduction of color for each month storage.—*H. H. Gerstein.*

**Final Report of Committee on Cross Connections.** Jour. New England W. W. Assoc., 43: 1, 79–112, March, 1929. Report of Committee on Cross-Connections defines and describes various types of cross-connections and makes following resolutions: (1) This Association recommends that no cross-connection be permitted with a supply that in the opinion of the state authorities is bacterially unsafe. (2) This Association recommends that any cross-connection permitted with a bacterially safe, but non-potable, supply shall be made through a properly installed and adequately supervised, all bronze, rubber-seated, double check valve of a type approved by the state health authorities. Description added of operation of automatic start-and-stop chlorinator for fire pumps.—*H. H. Gerstein.*

## ABSTRACTS SUB-COMMITTEE NO. 9

### Joint Research Committee on Boiler Feedwater Studies

**Boiler Corrosion and Pitting.** A. F. Stiglmeier. Boiler Maker, 29: 6, June, 1929, pp. 162 and (discussion) 162 and 164. Consideration of topic under following heads: boiler corrosion and pitting; what can be done in boiler department to relieve conditions. Report presented before Master Boiler Makers Assn.

**Boiler Corrosion and Wasting.** Power Engr. (Lond.), 24: 281, August, 1929, pp. 326–327, 1 fig. Internal corrosion mainly caused either by acid action of feedwater or by galvanic action; while external corrosion caused by dampness; some peculiar cases are discussed.

**Cause and Prevention of Internal Corrosion of Boilers.** W. D. HALSEY. Boiler Maker, 29: 5, May, 1929, pp. 139 and 140, 2 figs. A study of fundamental forms of corrosion which commonly occur in both power and locomotive-type boilers.

**The Formation of Scale in Boilers.** Engineer (Lond.), E. P. PARTRIDGE and A. H. WHITE. 147: 3832, June 21, 1929, p. 684. Article previously indexed from American Society of Mechanical Engineers—Advance Paper for met. May 13–16, 1929.

**Scale in Boilers of Central Heating Systems (Kesselstein in Zentralheizungskesseln).** W. BLEYERT. Gesundheits-Ingenieur (Munich), 52: 4, January 26, 1929, pp. 58–61, 4 figs. Observations of formation of boiler scale; methods of removing boiler scale, with particular reference to GROECK method.

**Water and Boiler Efficiency Problems—Emphasizing Subject of Corrosion.** W. B. LOWIS and G. S. IRVING. Eng. and Boiler House Rev. (Lond.), 42: 11, May, 1929, pp. 616–617. Effect of constituents in boiler practice can be predicted on three factors, namely scale-forming constituents, dissolved gases, and suspended matter in water or produced in boiler; salts usually found in feedwater are given and discussion of objective features cited of carbonates of calcium and magnesium, silica, and calcium sulphate. Extracts from paper presented before Engr. Surveyors' Assn.

**The Formation and Thermal Effects of Calcium Sulphate Boiler Scale.** E. P. PARTRIDGE and A. H. WHITE. American Society of Mechanical Engrs.—Advance paper for mtg. May 13–16, 1929, 11 pp., 7 figs. Fundamental study of manner in which calcium sulphate scale forms upon evaporative surface, redetermination of solubility values for calcium sulphate in boiler temperature range, and measurements of rate of formation and heat conductivity of calcium sulphate scales produced in experimental boiler; discussion of present knowledge concerning calcium sulphate scale.

**Boiler Explosions.** Metallurgist (Supp. to Engineer), May 31, 1929, pp. 65–66. Account of failure which occurred at iron works at Middlesborough; case of failure reported upon by Board of Trade Surveyor is clearly example of intercrystalline cracking at rivet holes; use of term "embrittlement" is misleading.

**Ageing and Recrystallization Tests on Boiler Plate (Alterungs-und Rekristallisationsversuche an Kesselblechen).** A. POMP. Zeit. des Bayorischen Revisions-Vereins (Munich), 33: nos. 1, 2 and 5, January 15 and 31 and March 15, 1929, pp. 7–9, 26–27 and 93–96, 30 figs. partly on supp. plate. Ageing is

accelerated by annealing of cold-worked steel; ageing tendencies of different steels vary greatly; results of strength and notched-bar tests to determine conditions governing both natural and artificial ageing and to obtain information on relation of temperature on notch resistance of aged material; 14 different steels 10 without alloy, and 4 with nickel additions were tested.

**Hair Cracks in the Surface of Plates (Haarrisse auf der Oberflaeche von Blechen).** E. A. Matejka. Archiv fuer das Eisenhuettenwesen (Duesseldorf), 2: 11, May, 1929, pp. 681–705, 47 figs. Tests carried out to investigate cause of hair-crack formation on plates are described in detail and results tabulated and illustrated; main cause is attributed to great difference between surface and internal temperature of rolled material.

**The Effect of Cold Working on Boiler Drums.** F. G. Straub, R. K. Hopkins and H. L. Whitney. Power, 69: 25, June 18, 1929, pp. 998–1002, 16 figs. Caustic embrittlement of boiler drums, due to high carbonate alkalinity, occurs where fabrication has set up internal strains in metal; results of experimental study of strains set up by various methods of fabrication are presented.

**Boiler Failures (Ueber Damfkesselschaeden).** R. Stumper. Waerme (Berlin), 52: 23 and 24, June 8 and 15, 1929, pp. 453–458 and 473–477, 18 figs. Importance of proper boiler-materials testing is emphasized; principal causes of failures; results of some investigations of boiler accidents; rivet-hole cracks in an old boiler; embrittlement of rivet due to superheating and poor material, or to cold working and ageing; crack formation in superheater tubes due to coarse grain recrystallization; corrosion of fire-tube boiler; transverse cracks in water tube due to heat stresses and corrosion.

**Reactions Occurring at High Pressures (Sur quelques réactions réalisées sous pression élevée).** E. Berl. Chimic et Industrie (Paris), 21: 3, March, 1929, pp. 452–465, 32 figs. Experimental study of explosiveness of mixtures of air and gas fuels, at various pressures; corrosion of iron in boilers at pressures of from 100 to 200 atmospheres.

**Boiler Operation at High Pressure Demands Exact Water Conditioning.** R. E. Hall. Power, 69: 22, May 28, 1929, pp. 873–875, 1 fig. Essential factors of exactitude in water condition for high-pressure operation; chemical reactivity between boiler metal and water; maintenance of thin protective film formed from and integral with surface of boiler, which defends metal against direct reaction of boiler and components therein; curve showing relation of acidity and causticity to protection of boiler metal.

**Corrosion Research Applied in Heating Engineering (Angewandte Korrosionsforschung fuer die Heizungsindustrie).** H. Balcke. Gesundheits-Ingenieur (Munich), 52: 4, January 26, 1929, pp. 49–53. Summary of recent research; prevention of corrosion in low-pressure boilers, water heaters, and hot-water heating systems.

**Boiler Feedwater Should be Free From Oxygen.** Power Plant Eng., 33: 10, May 15, 1929, pp. 566–568, 3 figs. Oxygen determinations should be made at first indication of corrosion; WINKLER iodimetric method taken from Chemists Subcommittee Report of Prime Movers Committee of Nat. Elec. Light Assn. is given in detail.

**Simple Method of Investigation for Water-Purification Plants (Ein einfaches Untersuchungsverfahren fuer Wasserreinigungsanlagen).** K. TAUSSIG. Archiv fuer Waermewirtschaft (Berlin), vol. 10, no. 7, July, 1929, pp. 249–252, 2 figs. Simple method for determination of hardness and alkalinity of pure water, and hardness, alkalinity, and soda content of boiler feedwater, is described.

**Standard Methods of Water Analysis.** H. FARMER. Fuels and Steam Power (A.S.M.E. Trans.), 51: 12, May–August, 1929, pp. 90–93, 5 figs. Report presents tentative method for determination of dissolved oxygen in boiler feedwater; application of test; WINKLER method for determining dissolved oxygen; summary of reagents; collection of sample; adding reagents; titrating sample; calculations; apparatus; tolerances.

**Regenerative Feed Heating.** D. M. SMITH. Elec. Times (Lond.), 75: 1963, June 6, 1929, pp. 884–886, 5 figs. Various feedwater-heating and drain systems are considered; cascade, separate drain-pump, drain-cooler and low-lift drain pump systems; decrease in heat consumption with regenerative turbine feed-heating in installation having economizer with and without air heater; graphs showing feed-heater drain arrangements.

**Report of Society Representatives on the Joint Research Committee on Boiler Feed Water Studies.** American Society Testing Materials.—Advance paper, no. 34, for mtg., June 24–28, 1929, 4 pp. Research is being carried on to determine fundamental principles underlying certain phenomena which take place in steam boilers; effect of water on metals occupies major part of program; résumé of more important subjects listed for investigation.

**Silicic Acid in Boiler Feedwater (Kieselsaeure im Kesselspeisewasser).** K. BRAUNGARD. Waerme (Berlin), 52: 15, April 13, 1929, pp. 277–280. Suggestions for preventing separation of silicic acid in boiler, set up by German Association of Large Boiler Owners, are supplemented and extended in present paper; notes on occurrence and quantity of silicic acid in natural waters, and view of leading authorities on possibilities and methods of separation, and rendering silicic acid harmless; possibilities of removing silicic acid outside of boiler.

**Boiler Room Chemistry Reduces Steam Troubles.** L. M. WILLIAMS. Refiner, 8: 1, January, 1929, pp. 98, 100 and 102, 3 figs. Description of water-treating plant built with equipment derived chiefly from junk pile at refinery in North Texas; details of practice in treatments of water that is high in dissolved solids, mostly sulphates and chlorides, by lime and soda-ash treatment.

**Boiler Water Concentration and Control.** Eng. and Boiler House Rev. (Lond.), 42: 10, April, 1929, pp. 550 and 552, 1 fig. Notes on principle which is now established in practice; ideal system of feedwater treatment should include: preheating and correct conditioning of crude water, control of water quality in boiler, continuous return system between boiler and softener, removal of necessary proportion of boiler water; economic utilization of water removed.

**Boiler Water Control.** Elec. West, 62: 6, May 15, 1929, pp. 441–442. Report of Boiler and Condensing Water Committee of Pacific Coast Electrical Assn., containing discussion of boiler-water control maintaining new standard ratio of sulphate to carbonate, by sulphate-phosphate treatment; reasons and reactions involved where make-up is from zeolite softeners, and condensate may be contaminated with seawater; brief statement of hydrogen-ion control as experienced by Pacific Gas and Electric Co.

**Control of Boiler-Water Treatment to Prevent Embrittlement.** F. G. Straub. Am. Soc. Mech. Engrs.—Advance paper for mtg., May 13–16, 1929, 2 pp. Author discusses necessity for boiler-room control of treatments used to prevent embrittlement; this control is based upon rapid and sufficiently accurate analysis which may be run readily by boiler attendants; analyses discussed are for total alkalinity, sodium sulphate, and sodium phosphate; details of colorimetric method for phosphate; recommends that all boiler-water analyses be checked from time to time by laboratories familiar with water analyses.

**Expert Supervision Necessary in Feed-Water Conditioning.** H. C. Dinger. Power, 69: 15, April 9, 1929, p. 589. Feed treatment based on water analysis and expert examination of boiler-operating conditions is advisable procedure; how to select compound.

**Feedwater Treatment in the Mining and Metallurgical Industry (Zur Frage der Speisewasseraufbereitung in Huetten-und Montanbetrieben).** W. O. Osenberg. Waerme (Berlin), 52: 16, April, 1929, pp. 293–299, 6 figs. Feedwater-treatment requirements for mining and metallurgical works are discussed; condensate recovery; evaporators in power and industrial plants; feedwater degasification; feedwater preheating.

**Points to Consider in Treating Feed Water.** H. C. Dinger. Power, 69: 16, April, 1929, pp. 630–631. Factors in determining arrangements for conditioning feedwater are: removal of air and corrosive and scale-forming ingredients from feedwater, involving distilling, pretreatment, filtering, etc.; after-treatment to correct conditions that have not been entirely overcome; proper blowdown procedure to eliminate collection of solids and sludge and to reduce concentrations of impurities in boiler; condition of make-up feed; application of protective surface film; alkalinity or pH control.

**Present Tendency of Boiler-Water Conditioning.** R. E. Hall. Combustion, 20: 2, February, 1929, pp. 90–92. Scope of boiler-water conditioning;

choice of equipment for attaining essential relations; maintenance of conditions, keynote of boiler-water conditioning; no consideration has been given to relative mechanical merits of different types of equipment. Abstract of paper read before Am. So. Mech. Engrs.

**Sampling Boiler Water for Testing and Guidance of Treatment.** S. C. PAGE. Universal Engr., 50: 1, July, 1929, pp. 25–27, 3 figs. Simple layout makes it possible to make competent test of boiler fluid that may save considerable expense and avert hazards of ignorance of boiler-water conditions; easily constructed device for securing boiler fluid for testing purposes and arrangement for drawing off liquid for testing and application.

**Some Results of Boiler Water Conditioning.** R. E. HALL. Iron and Steel Engr., 6: 6, June, 1929, pp. 380–389. Early development; general answer to question "how much soda ash to use;" classification of scale-forming and sludge-forming substances; second stage of development; phosphate for water conditioning; third stage of development; boiling conditions; HALL system methods of control; routine tests; reports of boiler water conditions; examples of water conditioning; analysis of various feedwaters.

**Suspended Matter in Boiler Feed Water.** R. BALDWIN. Elec. Rev. (Lond.), 104: 2669, January 18, 1929, p. 100. Author concludes that after chemical precipitation mechanical filtration is necessary.

**Influence of Chemicals in Boiler Feedwater on Steam-Cylinder Lubrication (Die Beeinflussung der Dampfzylinderschmierung durch Chemikalienzusatz zum Kesselspeisewasser).** G. SPETTMANN. Feuerungstechnik (Leipzig), 17: 7, April 1, 1929, pp. 75–77. Two examples of harmful effects are cited; only in case of feedwater composed mainly of calcium carbonate with very little magnesia and gypsum and only small quantities of soluble salts, are satisfactory results obtained with lime-soda process.

**Deconcentration: An Aspect of Boiler Control.** Chem. Age (Lond.), 20: 515 and 516, May 11 and 18, 1929, pp. 443–444 and 465–466. May 11: However much attention be paid to softening or other pretreatment of boiler water, progressive increase in its content of soluble salts still requires attention; exhaustive discussion of this aspect of boiler control is given; softening; salt transference; priming and foaming; conditions upon which foaming depends; increase in saline concentration; control of concentration; evaporation of make-up. May 18: Intermittent or periodical blow-down; economic aspect.

**Should Condensate from Steam Turbines be Again Degasified before Admission to Boiler? (Ist das Kondensat von Dampfturbinenanlagen vor der Kesselspeisung nochmals zu entgasen?)** H. SCHLICKE. Waerme (Berlin), 52: 22, June 1, 1929, pp. 442–443. Condensate from modern condenser installations is entirely free of gas and can be fed directly to boiler; but condensate from older plants must be collected and degasified before entering boiler.

**Removing Oil from Feed Water.** F. Grove-Palmer. Power, 69: 25, June 18, 1929, p. 1003. Dangers of oil present in form of emulsion in condensate and bulk of water are enumerated; analysis of condensate is suggested; application of oil separator; coagulation of oily emulsion by means of aluminum sulphate solution.

**Combating Boiler Corrosion.** C. H. Koyl. Boiler Maker, 29: 6, June, 1929, pp. 164–165. Presence of caustic soda in treated waters has nearly annihilated corrosion of all kinds; use of soda-ash on hard-water division between Perry, Ia., and Council Bluffs, Ia., has nearly done away with pitting; open feedwater heaters on these other divisions have not received care bestowed by original crew on first open heater placed four years ago on Sioux City Division. Paper presented before Master Boiler Makers Assn.

**Electric Current and Arsenic Check Boiler Corrosion.** Ry. Elec. Engr., 20: 5, May, 1929, pp. 145–149, 5 figs. Chicago and Alton has equipped boilers of 75 locomotives with electrochemical method of preventing boiler corrosion, known as Gunderson process, in order to create condition inhibitive to pitting and grooving; system is described and data gained from experience since September, 1924 are given.

**British Locomotive Boiler Practice.** A. Seton. Eng. and Boiler House Rev. (Lond.), 42: 12, June, 1929, pp. 650–652 and 654. Notes on boiler feedwater treatment and internal cleansing of boilers; American practice.

**Dearborn-Wagner Feedwater.** Ry. Age, 87: 2, July 13, 1929, p. 161. Features of appliance consisting of specially constructed dome and mud pocket installed on locomotive boiler at top and bottom of front course, respectively, which is standard equipment on Deutsche-Reischsbahn (German State Railway), with several thousand locomotives thus equipped.

**Zeolite Process for Softening of Locomotive Feedwater (Zeolithverfahren fuer Lokomotivspeisewaesser).** K. Braungard. Waerme (Berlin), 52: 23, June 8, 1929, pp. 462–464. American experiences with zeolite treatment of feedwater in railroad practice are discussed; comparison of base-exchange and precipitation processes; results obtained at plants of Southern Pacific Railroad; comparative costs for railroad practice of soda-lime and zeolite purification processes.

**The Corrosion Problem as Applied to Power Plants.** R. S. Rawdon and K. H. Logan. Fuels and Steam Power (A.S.M.E. Trans.), 51: 1, January–April, 1929, pp. 19–24, 7 figs. Discussion of corrosion problem as it relates both to inside and outside of power plant, that is, to generating of power and its transmission; boiler corrosion and water treatment; extent to which corrosion of boiler and allied equipment can be controlled by wise choice of material; corrosion from furnace combustion products; corrosion of overhead and underground transmission lines; failures of reinforced concrete. Paper presented before Midwest Power Eng. Conference.

**Factors Affecting Corrosion in Power Plants and Piping.** G. L. Biggs. Nat. Engr., 33: 8, August, 1929, pp. 375–377. Brief discussion of cause of corrosion; gases that promote corrosion; causes of corrosion in steam lines, corrosion in other systems.

**Determination of Dissolved Oxygen in Water (Bestimmung im Wasser geloesten Sauerstoffes),** Bach. Gesundheits-Ingenieur (Munich), 52: 3, January 19, 1929, pp. 36–37. Report of chemist of Emscher Genossenschaft (Emscher Union of Municipalities) describing modified James Miller method; water sample is colored with phenosofranine and is reduced with ferroammonium sulphate solution.

**Scale Formation in Cold and in Hot Water (Wasserstein im heissen unde kalten Wasser).** M. Groeck. Gesundheits-Ingenieur (Munich), 52: 7, February 16, 1929, pp. 97–102. Experimental study of factors and processes causing formation of boiler scale, protective coating deposits, and incrustations in containers and pipes carrying hot or cold water.

**The Cost of Softening Water by the Base Exchange Process.** H. G. Cathcart. Domestic Eng. (Lond.), 49: 3 and 4, March and April, 1929, pp. 47–51, 70–74, 7 figs. Brief discussion of typical plant of base-exchange type. Paper read before Instn. Heating and Vent. Engrs.

**Zeolite Treating Plants and Their Operation.** W. G. Watkins. Refiner, 8: 4, April, 1929, pp. 73–74. Chemistry of zeolite water softening; regeneration and salt requirements; softening efficiency. Reprint from Skelly News.

**Developments in Water Treatment.** O. A. De Celle and A. S. Behrman. Refrig. Eng., 17: 2, February, 1929, pp. 55–59, 4 figs. Manufacture of raw water ice from almost any water is reported to be possible with process of water purification discussed; object, and necessity, of water treatment in manufacture of raw water ice is briefly discussed in introduction; limitations of chemical treatment; principle of new process; application to ice; limitations of process; equipment; typical operating data.

**Municipal Water Supplies and the Effect of Trade Wastes in Relation to the Use of Water in Power-Plant Practice.** V. B. Siems. Fuels and Steam Power (A.S.M.E. Trans.), 51: 12, May–August, 1929, pp. 87–89. Report enumerates factors contributing to water-supply pollution, feedwater problem, and condenser operation difficulties encountered in steam power plant practice; recommendations for control of stream pollution. Bibliography.

**Water Plant Follows Indian Design.** F. Kutnewsky. Water Works Eng., 82: 3, January 30, 1929, pp. 139–140 and 148, 4 figs. Plant at Albuquerque, N. M., has maximum daily capacity of 6,000,000 gal.; water treated for iron and hardness, filtered and chlorinated.

(*Items from "Chemical Abstracts" contributed by Dr. A. M. Buswell*)

**Apparatus for Separating Oil from Boiler-Feed Water.** SHORT, THOMAS A. U. S. 1,708,033, April 9. Chem. Abstract 23: 10, 2521, May 20, 1929. An alarm device is provided for indicating when oil accumulates in the feed-water supply.

**The Classification and Evaluation of Boiler-Feed Water.** STUMPER, R. Wärme, 51: 717, 1928; Wasser u. Abwasser 25: 207. Chemical Abstracts, 23: 12, 3038, June 20, 1929. Determinations of Ca, Mg, $HCO_3$ and total hardness of boiler-feed waters give important data on scale formation in boilers and aid greatly in evaluating a water for steam generation.—*C. R. Fellers.*

**The Influence of Magnesium Content on the Hardness of Boiler-Feed Waters.** HERMANN, P. Wärme, 512: 755-7, 1928; Wasser u. Abwasser, 25; 207. Chemical abstracts, 23; 12, 3038, June 20, 1929. Mg in water cannot be removed by chemical means. Large amounts of Mg cause scale formation.—C. R. F.

**Preventing Incrustation in Boilers.** BARDT, H. Brit. 294,658, July 29, 1927. Chem. Abs., 23: 8, 1978, April 20, 1929. Scale deposition in steam boilers is prevented by use of a mixture of activated C and a metal powder such as Cu which is electronegative to Fe.

**Preventing Incrustation in Boilers.** GORDON, J. Brit. 299,073, May 17, 1927. Chem. Abstracts, 23: 12, 3043, June 20, 1929. A soluble carbonate is added to the boiler water in such proportions that Ca is precipitated as carbonate, which forms a non-adherent sludge. The conditions of the treatment are also favorable for the precipitation of Mg and Fe salts, silicates, and some other impurities in non-adherent form. $Na_2CO_3$, $NaHCO_3$ or $BaSO_4$. A chart of different concentrations suitable for adding phosphate to the boiler water to precipitate Ca phosphate as a sludge. A fluoride or arsenate also may be used for the production of a non-adherent precipitate. Most of the Ca and Mg are preferably removed by a preliminary treatment with lime and $Na_2CO_3$. A chart of appropriate concentrations of reagent is given.

**Preventing Incrustation in Boilers.** KITCHIN, BORIS (to Filtrators Co.). U. S. 1,704,390, March 5. Chem. Abstracts, 23: 8, 1978, April 20, 1929. A device is described in which vegetable material such as flax-seed is placed, to which steam is supplied, and from which condensate is led to the boiler water.

**Preventing or Removing Boiler Incrustation.** Riedel-E., J. D. and De Haën, A.-G. Ger. 474,272, November 21, 1922. Chem. Abs., 23: 12, 3043, June 20, 1929. Water-insoluble inorganic substances, e.g., alumina, kaolin, or graphite, are kept in colloidal suspension in the water.

**Preventing Incrustation in Boilers.** LAZARUS, W. Brit. 294,224, July 21, 1927. Chemical Abstracts, 23: 8, 1978, April 20, 1929. The process described in Brit. 283,517 (C. A. 22: 4193) is modified by the use of alkaline earths such

as $BaCO_3$ or $Ba(OH)_2$ instead of alkali or alkali metal carbonate for treating the hardness remaining after boiling.

**Softening Water.** Hans Reisert & Co. Komm.-Ges. Auf Aktien. Ger. 471,982 December 24, 1922. Chem. Abstracts, 23: 13, 3290, July 10, 1929. The feed water for steam boilers is divided into 2 portions before feeding. One portion is treated with a basic softening agent and the other with led-back boiler water.

**Superposed Tray System for Purifying Feed Water for Boilers.** Pecz, Kornel and Rejtö, Karl (to Nathan Mfg. Co.), U. S. 1,705,095, March 12. Chemical Abstracts, 23, 8, 1978, April 20, 1929.

**The Use of Chemically Prepared Feed-Water for High-Pressure Boilers.** Splittergfrber, A. Wärme, 51: 733–9, 1928; Wasser u. Abwasser, 25: 207. Chemical Abstracts, 23: 12, 3038, June 20, 1929.—*C. R. Fellers.*

## NEW BOOKS

**Eighth Annual Report of Ohio Conference on Water Purification, November 1–2, 1928. (1929). Operation of the McDonald Water Softening Plant.** T. S. Woodward. 13. A brief outline. The water supply, obtained from an abandoned coal mine, is hard and contains a considerable amount of Fe. Lime softening is employed, which also removes the Fe. **Operation of the Water Softening Plant at Leroy.** A. E. Kimberly. 13. Although the population is but 350, Leroy has a 25,000-gallon per day, intermittently-operated softening plant. The hardness of the well water is 570 p.p.m. and of the softened water, 85. Air agitation is employed. The filter sand is becoming incrusted. **Operation of the Westerville Water Softening Plant.** J. H. Wenger. 13–14. The softening plant of Westerville, constructed at a cost of $49,000, consists of dry feed lime, soda, and alum machines, 2 mechanical mixing chambers, 2 coagulation basins and two 300,000-gallon per day filters. The hardness of the raw water, derived principally from Alum Greek, averages about 300 p.p.m., and of the softened water, about 90 p.p.m. The cost of chemicals for softening and coagulation averages about $28 per million gallons. **Operation of the Medina Water Softening Plant.** A. H. Fretter. 14–5. The water supply of Medina, derived from a small creek, is hard and at times very turbid and carries a high bacterial load. The softening and filter plant has a capacity of 1 million gallons per day and consists of chemical feed machines for lime, $Na_2CO_3$, and alum, a gravity mixing chamber, 2 coagulation basins with $CO_2$ diffusers at the effluent end, and 2 filters. Prior to adopting carbonation, considerable incrustation of the filter sand occurred. The $CO_2$ is generated by burning coke; gas containing 12–18 per cent $CO_2$ being easily obtained. From 3 to 4 per cent escapes without being absorbed by the water. The gas is drawn from the flues by water injectors, the throats of which are made of brass, Fe having been found to last only 6 weeks. The coke consumption is about 200 pounds per million gallons. **Use of Pulverized Quick Lime at Portsmouth.** F. E. Sheehan. 21–2. Lime treatment is employed at Portsmouth to reduce the $CO_2$ content, and excess lime treatment is substituted for chlorination when the

raw water contains phenol. Arching of $Ca(OH)_2$ in the hoppers of dry feed machines and troubles with insoluble cores in pebble lime led to the use of ground burnt lime. Shipped in steel containers or paper-lined burlap sacks, it retains its CaO content indefinitely. It can be applied through dry feed machines without difficulty. There is no heat developed during slaking and the reaction is complete. The unit cost is somewhat less than for $Ca(OH)_2$. **Desirability of Metal Instead of Concrete for Exposed Open Flumes.** J. M. Montgomery. 22. The concrete flume between the mixing tanks and the Dorr clarifier in the Piqua softening plant failed after being 2 years in operation and has been replaced with a flume of steel boiler plate. Frost action was particularly severe at the water line. J. W. Ellms reported disintegration of the concrete in the filters at Cleveland. **Experiment on Using Broken Stone Instead of Gravel in Filter Bottoms.** O. F. Schoepfle. 23–4. A 4-inch layer of 2½-inch hard dolomitic limestone was placed beneath the original gravel during reconstruction of one of the filters of the Sandusky plant in June, 1928. No trouble has since been experienced with gravel inversion in this filter, no hard spots have developed, and the distribution of the wash water is very even. Successful use of crushed stone at other plants was reported, the irregular-shaped rock staying in place better than grounded gravel. **The Use of Steel vs. Concrete for Wash Water Tanks.** 24. A **Discussion** of the relative merits of steel and concrete, in which experience at several plants is outlined. The chief difficulty with the former is leakage, and with latter, painting and repairing while in operation. **A Small Sand Washer and Gravel Grader.** F. E. Sheehan. 25–6. A description of a machine used during reconditioning of the filters at Portsmouth. **The Use of Carbon Dioxide Scrubber Water for Removing Sand Incrustation.** J. M. Montgomery. 26–7. Carbonation is effected at Piqua with $CO_2$ produced by burning coke, the gas being scrubbed before being applied to the water. Recently the water used for scrubbing has been passed upwards through the filter beds to remove the incrustation on the sand resulting from excess lime softening. The alkalinity of this water after passing through the sand has been found to be as high as 1000 p.p.m. In the **Discussion** which followed, the possibility of corrosion being caused by this practice was suggested. C. P. Hoover suggested recarbonation in 2 stages, near the outlet of the mixing chamber and at the inlet to the filters, to prevent sand incrustation. **The Lima Water Purification Plant.** E. E. Smith, 2nd. 31–8. The sources of the Lima water supply are Lima Lake and Lost Creek reservoir, into both of which Ottawa River water is pumped. The filter plant, which has a capacity of 8 million gallons per day, consists of chemical feed machines, carbonation equipment, 2 baffled mixing basins, 2 coagulation basins, 6 rapid sand filters, and chlorination apparatus. Application of $CuSO_4$ in the receiving reservoirs has been found to be an effective remedy for short filter runs due to algae. Since 1925, $CO_2$, generated by burning coke, has been applied to the water for reducing the alum dosage. The water is hard, averaging about 222 p.p.m. Suggested plant changes to permit softening to be carried out are outlined. **New Water Supply and Water Purification Plant at Wellston.** F. E. Sheehan. 39–42. The water supply of Wellston, obtained from Little Raccoon Creek and Lake Alma, is treated in a 2-million gallon per day plant consisting of aërator nozzles surrounded by a louvre wall, mechanical mixing cham-

bers, coagulation basin, 2 rapid sand filters, and chlorination equipment. The chambers of the rate controllers serve as effluent sight wells or turbidimeters. Tabulated data on the purification effected during 1928 are included. **Proposed Re-Sanding of the Cincinnati Filters.** CLARENCE BAHLMAN. 43–4. The Cincinnati filters, after 21 years' service, are to be re-sanded. The effective size of the sand has increased from 0.34 to 0.50 mm., and the acid-soluble content from 1.1 to 50.8 per cent. The incrustation, an analysis of which is given, has increased the depth of the sand bed from 30 to 38.5 inches. No decrease in efficiency due to the coarser sand has been observed. Sand loss during washing is confined to the winter months, probably due to the greater density of the cold water. The reconstructed bed will contain 14 inches of gravel and 28 inches of sand. A portion of the old sand will be mixed with new Ohio River sand, purchased at $1.60 per ton delivered. The equipment used for grading the sand is described. Approximately 73 per cent of the new crude sand is being utilized. In **Discussion,** J. W. ELLMS reported that more sand was lost during washing in winter at Cleveland also, due to the greater viscosity of the cold water. During hot weather a 39-inch rise of wash water can be employed, while in winter the rate is reduced to 24 inches per minute. **Water Softening for Small Municipalities.** CHARLES P. HOOVER. 45–52. A general discussion of water softening for cities with water consumption up to 1 million gallons per day, and a description of the softening plants at Batavia and New Richmond. The softened water should have a hardness of 70–80 p.p.m. The plant at Batavia, treating Little Miami River water, is of the fill and draw type and consists of chemical feed equipment, 2 settling basins, carbonation chamber, and two 0.25-million gallon per day rapid sand filters. Mixing is effected by compressed air. The $CO_2$ generating equipment consists of a combined oil furnace, washer, scrubber, and dryer. The limesoda plant at New Richmond consists of 2 wells, chemical feed devices, a combined mixing (baffled) and settling tank, recarbonation equipment, and 2 pressure filters; the rated capacity being 0.864 million gallon per day. In **Discussion,** the Glendale fill and draw, lime-soda plant was described. The well water has a hardness of about 290 p.p.m., and the softened water usually varies between 50 and 60. Recarbonation is not employed and the filter sand and hot water pipes are becoming incrusted. **The Lowellville Zeolite Water Softening Plant.** W. H. KNOX. 53–5. The new zeolite softening plant at Lowellville is the first municipal plant of this type in Ohio. The capacity is 350,000 gallons per 24 hours, but it is only operated for 6 hours each day. The water flows upwards through 2 feet of gravel and 9 feet of zeolite. For regeneration, brine is applied to the top of the filter. The wash water used is approximately 6 per cent of the water softened. The raw well water, which has a hardness of 285 p.p.m., is mixed with the softened water in the proportion of about 19 to 81, giving a product of about 80 p.p.m. hardness. The chemical cost is about 2.8 cents per 1000 gallons of water softened, or 1.36 cents per 1000 gallons per 100 p.p.m. reduction in hardness. The cost of pumping is 3.14 cents per 1000 gallons. **Bactericidal Action of Lime in Sub-Caustic Doses.** CLARENCE BAHLMAN. 56–9. Excess lime treatment, sufficient being added to give a caustic alkalinity of 5 p.p.m., has been successfully employed at Cincinnati on occasions when chlorination has been suspended on account of taste. Recent observa-

tions and experiments have shown that greater bacterial removals are obtained when more lime is added than required for coagulation, but not sufficient to produce causticity. With normal iron and lime treatment, 30 to 45 per cent of the filter influent alkalinity is in the form of normal carbonates and the pH value ranges from 9.0 to 9.3. When using the higher lime dosages experimented with, which were 70 to 90 per cent higher than normal, 50 to 80 per cent of the alkalinity was normal carbonate and the pH was 9.4 to 9.5. Markedly better *B. coli* reductions were obtained under the latter conditions. B. believes that the higher removals were more probably due to improved coagulation than to destruction of the organisms, the filter effluent always being more brilliant with the increased lime dosages. The method of treatment is suggested for combating unusual pollution. Continuous use would result in sand incrustation. D. H. Rupp, in **Discussion,** stated that a caustic alkalinity of 15 p.p.m. at Oklahoma City results in a considerable reduction in bacterial content, but does not effect sterilization. **Research on Removal of Phenolic Tastes in Public Water Supplies.** R. D. Scott. 60–3. Results are given of bottle experiments on the treatment of water containing 0.01, 0.1, and 1 p.p.m. of phenol. The $Cl_2$ consuming power of ammonia still liquor in distilled water was found to be nearly 1 p.p.m. per 1 p.p.m. of phenol after 20 hrs. contact and the $O_2$ consumed value, 2.6 p.p.m. per 1 p.p.m. of phenol. The $O_2$ consumed value of pure phenol was 1.8 per 1 p.p.m. The minimum concentration of phenol which will cause a taste on chlorination varies with different waters, e.g., at Columbus, 10 parts per billion in the raw water and 0.2 parts per billion in the filtered. The minimum concentration of phenol detectable by taste in the absence of $Cl_2$ is 1 p.p.m. In experiments on superchlorination, it was found that the dosage required seemed to depend on the $Cl_2$ absorption in 20 hrs. Only a slight residual need be present at the end of this period. Progressive increases in $Cl_2$ dosage did not result in corresponding increases in residual $Cl_2$. It is suggested that the dosage required to produce the first progressive increase in residual $Cl_2$ might be designated the *superchlorination value* of the water, the data indicating that this value is a measure of the $Cl_2$ dosage required to eliminate chlorophenol tastes. Addition of $KMnO_4$ reduces the $Cl_2$ required to eliminate taste, 1 p.p.m. $KMnO_4$ being as effective as 4 p.p.m. $Cl_2$, as compared with their relative oxidizing powers of 1 to approximately 0.9. Addition of ammonia prior to $Cl_2$ in proportion of 0.5 to 1 prevented the production of taste from 0.1 p.p.m. phenol when $Cl_2$ dosages up to 0.5 p.p.m. were employed. Slight taste developed with higher $Cl_2$ applications. The residual $Cl_2$ content is higher with $Cl_2$ and ammonia treatment than with $Cl_2$ alone and increases directly with the proportion of ammonia used. Taste prevention by this method is probably due to the fact that the affinity of chloramine for organic matter is less than that of $Cl_2$. E. Watzl discussed the use of activated carbon C for dechlorination. The ratio of carbon destruction to $Cl_2$ removed is approximately 1:6. The products are $CO_2$ and HCl. Filtration rates of 24 to 72 gallons per square foot per minute can be maintained through beds of carbon 5 feet deep. The most suitable size of carbon is 0.2-inch. **The Phenol Recovery and Treatment Works of the Hamilton Coke and Iron Company, Hamilton, Ohio.** B. F. Hatch. 64–9. An illustrated description of the phenol recovery plant recently placed in operation by the Koppers Co., at the works of

the Hamilton Coke and Iron Co. Ammonia is recovered by the direct process, the volume of waste from the still being approximately 30 gallons per ton of coal coked, or 35,000 gallons per day. The process consists essentially in passing an inert gas saturated with steam in a closed cycle through the hot partially-distilled liquor, which is taken from the bottom of the free still before it enters the lime leg and sprayed into the top of a steel tower consisting of a dephenolizing section with 3 NaOH scrubbing sections below. A mixture of approximately 90 per cent steam and 10 per cent air or other inert gas, blown in counter current direction to the waste, maintains the temperature in the tower just below boiling point and vaporizes the tar acids. The mixture of steam and gases is drawn from the top of the tower and introduced into the NaOH scrubbing chambers below, where the phenol is retained, the steam and inert gas again passing up into the dephenolizing section. Fresh NaOH solution is continuously applied to the uppermost of the 3 scrubbing sections and the partially-spent NaOH is recirculated through the other two. The resulting PhONa is sprung with stack gas, the phenol being drawn off in saleable form. The dephenolized liquor is returned to the still and the final effluent discharged into a pond. The phenol content is reduced from 2.5–3.0 g. per liter, to below 100 p.p.m., i.e., a removal of 95 per cent, or better. The cost of the process is not burdensome. **Results Obtained in Phenolic Wastes Disposal under the Ohio River Basin Interstate Stream Conservation Agreement.** F. H. Waring. 70–80. An extensive review of the phenol waste problem and methods of treatment of ammonia still liquor, with particular reference to conditions in the Ohio River basin. Details are included of the Ohio River interstate conservation agreement, one provision of which is that signators will promptly notify downstream or adjacent signators of unusual events affecting the Ohio River or its tributaries, such as phenol spills, typhoid epidemics, etc. Of the 18 plants in the Ohio basin which have phenol wastes to dispose of, only 2 have not complied with the requirements regarding installation of phenol elimination systems. The quenching system of disposal is unsatisfactory and is costly, both to instal in an existing plant and to maintain. Other methods of treatment include extraction of the phenol with benzol or light oil, distillation in a specially constructed ammonia still in which phenol is collected in the distillate as $PhONH_4$, and the Koppers phenol recovery process (cf. previous abstract).—*R. E. Thompson.*

**Industrial Carbon.** C. L. Mantell. D. Van Nostrand Co., 410 pp., 1928. In his preface the author states that he has attempted to cover the technologic application of elemental carbon aside from its use as a fuel.

"The contents of this volume fall naturally into several subdivisions,—the truly elemental forms such as diamonds and graphites, with their industrial phases; carbon pigments and fillers, such as carbon black, lampblack and other blacks; adsorbent carbon of the gas, decolorizing and metal adsorbent types. with which bone black is grouped; and the manufactured carbon products, such as electrodes, brushes, etc. A reference chapter on the physical characteristics of carbon is included."

Heretofore the literature on carbon has been so widely scattered, and in some instances of such conflicting opinions, that it has been difficult for the reader

**to arrive at definite conclusions. That a book covering the various uses of carbon, other than for heating, has been needed for some time is evident. The author is to be commended on the manner in which he has handled the entire subject in one volume.**

**The water chemist will be interested more particularly in the chapters on gas adsorbent charcoal, bone black, vegetable decolorizing carbon, and metal adsorbent chars. The book discusses the fundamentals of adsorption by the active carbons very thoroughly and gives much information that will enable one to form some idea of what to expect when activated carbon is used in water treatment, although the removal of objectionable tastes and odors from water is not discussed.—*John R. Baylis.***

**California. Surface Water Supply of the Sacramento River Basin, 1895–1927. H. D. McGlashan. U. S. Geol. Survey. Water-Supply Paper 597-E.—*Arthur P. Miller.***

**California. Surface Water Supply of the United States, 1925. Part XI. Pacific Slope Basins. Nathan C. Grover, H. D. McGlashan, and F. F. Henshaw. U. S. Geol. Survey. Water-Supply Paper 611.—*Arthur P. Miller.***

**Washington. Surface Water Supply of the United States, 1925. Part XII. North Pacific Slope Drainage Basins. A. Pacific Basins in Washington and Upper Columbia River Basin. Nathan C. Grover, G. L. Parker, and W. A. Lamb. U. S. Geol. Survey Water-Supply Paper 612.—*Arthur P. Miller.***

**Montana. Ground Water in Yellowstone and Treasure Counties. G. M. Hall and C. S. Howard. U. S. Geol. Survey. Water-Supply Paper 599.—*A. P. Miller.***

**Industrial Effluents, Their Purification, Disposal and Economic Utilization. B. Bohm, 1928. Published by Otto Elxner, Verlagsgesellschaft, m.b.H., Berlin). Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 1, C-4, November, 1928. (1) A general review of the subject including a consideration of the injurious effects of wastes on streams and of the possibilities of the practical utilization of industrial effluents; (2) The general methods of purification of waste waters —self purification, mechanical devices, screens, etc., sedimentation, chemical methods, natural and artificial biological methods; (3) the methods of purification suitable to particular industries; (4) precautions taken by the Authorities to preserve the purity of streams. In an appendix an abstract is given of the regulations obtaining in Prussia and in other German States with regard to the discharge of effluents into streams.—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).***

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